IMPLEMENTATION OF A FIXED-BASE SPIN SIMULATOR

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THESIS

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September 1972

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
September 1972

ABSTRACT

This report discusses the design and implementation of a fixed-based spin simulator and the results derived from conducting preliminary spin tests on the simulator.

The central piece of equipment in the simulator was a hybrid computer in which the analog computer solved the equations of motion while the digital computer performed the tasks of program control and aerodynamic data storage. The visual display consisted of a computer-drawn picture on a graphics terminal, while pilot control was obtained by use of a simulated cockpit situated in front of the graphics terminal.

Results showed that the simulator displayed excellent dynamic response characteristics and provided sufficient visual cues to perform meaningful spin tests.

This project was a continuation of previous work and has shown that the design and construction of this simulator has been an excellent research tool and source for further study in the field of control systems and aircraft dynamics.

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LIST OF SYMBOLS

b	Wing span, ft.
C_l	Rolling moment coefficient
$C_{l_{\delta a}}$	Aileron control effectiveness derivative
$C_{l_{\delta r}}$	Rolling moment coefficient due to rudder deflection
C_{l_p}	Damping in roll derivative
C_{l_r}	Rolling moment coefficient due to yawing
C_m	Pitching moment coefficient
$C_{m_{\delta it}}$	Elevator control effectiveness derivative
C_{m_q}	Pitch damping derivative
C_n	Yawing moment coefficient
$C_{n_{\delta a}}$	Aileron yaw derivative
$C_{n_{\delta r}}$	Rudder control effectiveness derivative
C_{n_p}	Yawing cross derivative
C_{n_r}	Damping in yaw derivative
C_x	Longitudinal-force coefficient
$C_{x_{\delta it}}$	Longitudinal-force coefficient due to elevator deflection
C_{x_q}	Longitudinal-force coefficient due to pitching
C_y	Side-force coefficient
$C_{y_{\delta a}}$	Side-force coefficient due to aileron deflection
$C_{y_{\delta r}}$	Side-force coefficient due to rudder deflection
C_{y_p}	Side-force coefficient due to rolling
C_{y_r}	Side-force coefficient due to yawing
C_z	Vertical-force coefficient

$C_{z_{\delta it}}$ Vertical-force coefficient due to elevator deflection

C_{z_q} Vertical-force coefficient due to pitching

$\bar{c}$ Wing chord, ft.

$F_{x_{aero}}$ Aerodynamic force in X body axis direction, lb.

F_{x_s} Total force in X stability axis direction, lb.

F_{x_w} Total force in X wind axis direction, lb.

$F_{y_{aero}}$ Aerodynamic force in Y body axis direction, lb.

F_{y_s} Total force in Y stability axis direction, lb.

F_{y_w} Total force in Y wind axis direction, lb.

$F_{z_{aero}}$ Aerodynamic force in Z body axis direction, lb.

F_{z_s} Total force in Z stability axis direction, lb.

F_{z_w} Total force in Z wind axis direction, lb.

g Acceleration due to gravity, 32.2 ft/sec^2

I_{xx} Moment of inertia about X body axis, slug-ft^2

I_{xz} Cross product of inertia, slug-ft^2

I_{yy} Moment of inertia about Y body axis, slug-ft^2

I_{zz} Moment of inertia about Z body axis, slug-ft^2

L Rolling moment about body axis, ft-lb

M Pitching moment about body axis, ft-lb

m Mass of aircraft, slug

N Yawing moment about axis, ft-lb

P Rolling rate about body axis, rad/sec

P_s Rolling rate about stability axis, rad/sec

$\bar{P}$ Normalized rolling rate about body axis

Q Pitching rate about body axis, rad/sec

Q_s Pitching rate about stability axis, rad/sec

$\bar{Q}$ Normalized pitching rate about body axis

q	Free stream dynamic pressure, lb/ft^2
R	Yawing rate about body axis, rad/sec
R_s	Yawing rate about stability axis, rad/sec
$\bar{R}$	Normalized yawing rate about body axis
S	Aerodynamic reference area, ft^2
$\dot{S}_x$	$\dot{X}$
$\dot{S}_y$	$\dot{Y}$
$\dot{S}_z$	$\dot{Z}$
T	Thrust of aircraft, lb.
V	Velocity of aircraft, ft/sec
X	X inertial coordinate of aircraft, ft.
Y	Y inertial coordinate of aircraft, ft.
Z	Z inertial coordinate of aircraft, ft.
α	Angle of attack, deg.
β	Angle of sideslip, deg.
δa	Aileron deflection angle, deg.
δit	Elevator deflection angle, deg.
δr	Rudder deflection angle, deg.
ϕ	Euler roll angle, deg.
ψ	Euler yaw angle, deg.
θ	Euler pitch angle, deg.
$(\dot{\ })$	$d(\ )/dt$

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to: Lieutenant (junior grade) Michael Redlin, Assistant Professor of Aeronautics, for his invaluable guidance, time and assistance during the course of this project; Robert Limes, William Thomas and Al Wong, of the Department of Electrical Engineering Computer Laboratory, for their assistance in the running of the program.

I. INTRODUCTION

The purpose of this project was a continuation study of the work done by J. H. Kahrs [Ref. 1]. Kahrs made the initial design and construction of a fixed-based variable-stability simulator with the task of landing on a carrier or runway. The intent here was to make the necessary modifications and adjustments to this simulator in order to develop a simulator capable of evaluating the spin characteristics of various aircraft.

The same basic equipment, i.e. the hybrid computer, graphics terminal, and the cockpit simulator, was used as constructed by Kahrs. The hybrid's analog computer was used for the solution of the equations of motion of the aircraft, while the hybrid's digital computer was used for overall program control, graphics generation, data reduction and storage. The visual display was created by a graphics processor and terminal. The cockpit simulator, situated in front of the graphics display, consisted of a chair with various control levers and buttons whose outputs were tied directly to the analog computer, thus giving the operator a direct means of controlling the simulator. This combination of computers and control linkages comprised the basic hardware of the simulator and formed a complete control loop as diagrammed in Figure 1.

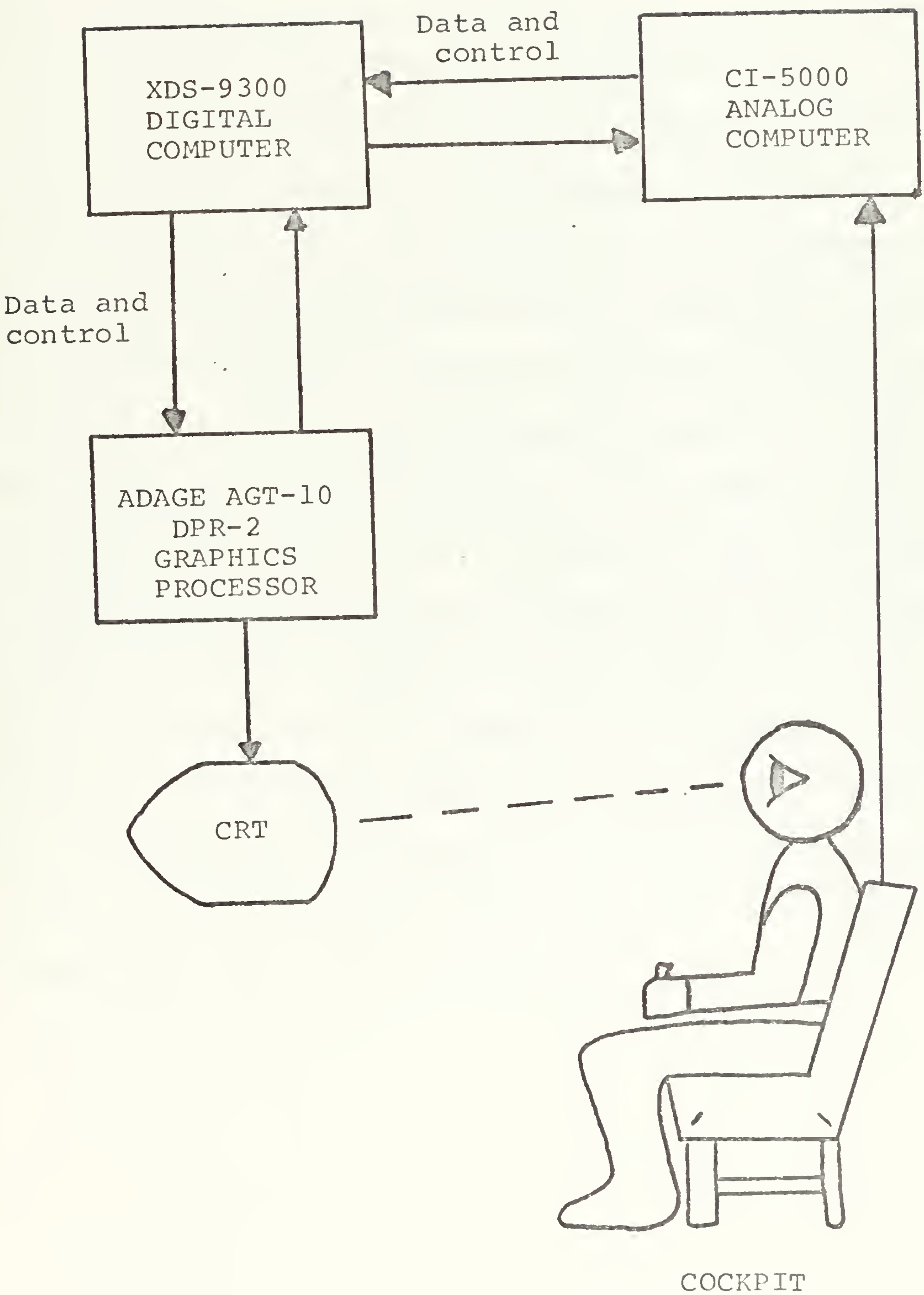


Figure 1. Simulator Control Loop.

The simulator, in the above format, provided the necessary and required operating and handling characteristics. These characteristics, as originally designed by Kahrs, included (1) simplicity of setup and operation, (2) ability to change aircraft being simulated, (3) capability of simulating non-linear aerodynamic data, (4) automatic scaling of the analog computer solution, (5) fixed-base inside-out display, and (6) ability to expand or change simulator task.

The two most important characteristics desired in this project were the ability to expand and change simulator task and the ability to change aircraft being simulated. Major revisions in the internal programming were needed to account for the large differences in the aircraft's flight characteristics between the landing phase and the spin phase. These differences included the addition of the non-linearized equations of motion that are needed in the solution of the spin problem. The ultimate goal was to verify that this simulator was capable of providing a realistic simulation of a spin from a pilot's point of view and at the same time obtain meaningful data for further study.

II. THE SIMULATOR

The simulator consisted of three basic pieces of equipment; the hybrid computer, the graphics terminal, and the cockpit simulator. The hybrid computer was used due to the outstanding qualities obtained by use of the digital computer in conjunction with the analog computer. Due to the rapid computational time of the digital computer the bulk of the work load was assigned to it. This included the resolution of the forces and moments, build-up of graphics data, and the non-linearities of the aerodynamic coefficients. The analog computer, on the other hand, was used for integration of the equations of motion and interfacing. This also provided the most rapid means of obtaining a desired output. The important feature involved throughout was obtaining the desired output data by the fastest means possible. This assured that the simulator had an excellent dynamic response and led to a display with as little flicker as possible and overall graphic quality.

The graphics terminal consisted of a graphics processor and visual display unit (CRT). Construction of the display data was accomplished by the digital computer. These data were sent to the graphics processor where a computer-drawn picture was formed on the CRT. As new data were compiled by the digital computer, the graphics processor would update and refresh the visual display, thus providing the pilot with a continuous picture.

The cockpit simulator was a chair, with attached controls, placed in front of the CRT. A Gemini control stick was attached to the right arm and provided all three control movements: yaw, pitch, and roll. Two programs control buttons were provided. One control button was located on the top of the stick, while the second control button was located on a throttle plate attached to the left arm along with a small throttle control. All outputs of the cockpit were connected directly to the analog computer for processing, thus providing the pilot with the necessary controls to run the problem from his station. A complete operating manual is contained in Appendix E.

The simulator was designed to accept the following input data in the form of punched cards: aerodynamic coefficients; initial conditions (initial position, altitude, velocity, etc.); aircraft constants (weight, moments of inertia, wing span, etc.); scale factors based on maximum expected range of the problem's variables; and an earth reference grid. Appendix F outlines the preparation of this data deck.

The simulator then automatically processes these data, sets the potentiometers of the analog computer, and sets the initial conditions on the integrators. Control is then transferred to the cockpit where the pilot has three options available:

1. To fly the simulator with the further option of aborting the run at any time and returning to fly again with the same aircraft parameters.

2. To input a new data deck to change the simulated aircraft's parameters or to change aircraft being simulated.

3. To stop the complete problem.

At the completion of each run an analysis of the run is briefly displayed on the CRT after which instructions for further program control are displayed. The analysis of the run consists of the following items:

1. Final angle of attack
2. Final pitch angle
3. Final roll angle
4. Final yaw rate
5. Final velocity
6. Final altitude

III. SIX DEGREE OF FREEDOM AIRFRAME EQUATIONS

Three different coordinate systems--body, wind, and stability axes--were available for problem solution. It was concluded, on the basis of work done by R. M. Howe [Ref. 2] and J. H. Kahrs [Ref. 1], that the best choice of the coordinate systems was a combination of the wind axes system and the body axes system. The translational equations of motion would be based on the wind axes system while the rotational equations were based on the body axes system. The three coordinate systems are shown in Figure 2. The stability and body axes system differ by the aircraft's angle of attack, while the wind and stability axes system differ by the side-slip angle.

With a knowledge of the three angular rates of motion of the aircraft (P,Q,R) about the body axes, normalized values for P, Q, and R are obtained.

$$\bar{P} = \frac{Pb}{2V} \tag{1}$$

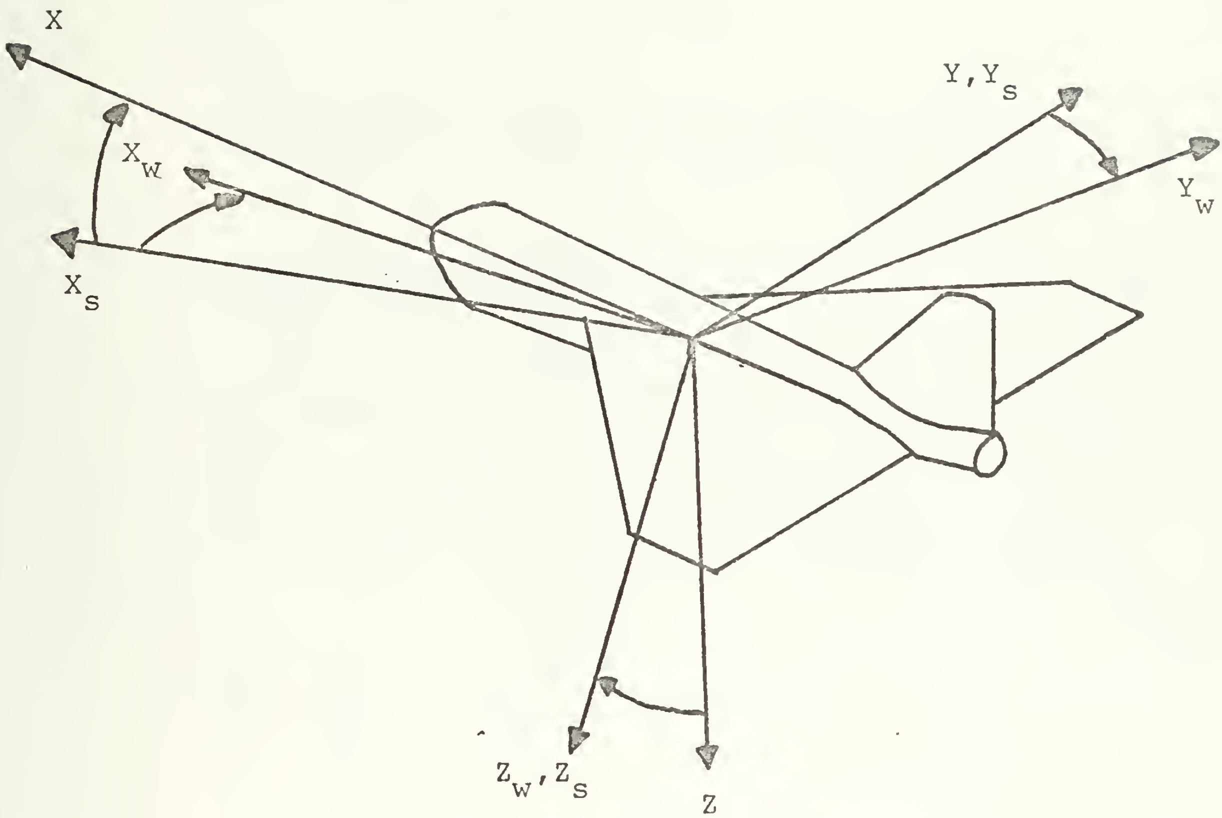
$$\bar{Q} = \frac{Qb}{2V} \tag{2}$$

$$\bar{R} = \frac{Rb}{2V} \tag{3}$$

The angular rates about the stability axes are determined as functions of P, Q, and R (Eqn. 4-6).

$$P_s = P \cos\alpha + R \sin\alpha \tag{4}$$

$$Q_s = Q \tag{5}$$



X,Y,Z - Body axes

X_s, Y_s, Z_s - Stability axes

X_w, Y_w, Z_w - Wind Axes

Figure 2. Aircraft Coordinate Axes.

$$R_s = P \sin\alpha + R \cos\alpha \tag{6}$$

The aerodynamic forces expressed in the body axes can now be calculated.

$$\frac{F_{x_{aero}}}{m} = \frac{Sq}{m} \left(C_x + \delta it\, C_{x_{\delta it}} + \bar{Q} C_{x_q}\right) \tag{7}$$

$$\frac{F_{y_{aero}}}{m} = \frac{Sq}{m} \left(C_y + \bar{R} C_{y_r} + \bar{P} C_{y_p} + \delta_r C_{y_{\delta r}} + \delta_a C_{y_{\delta a}}\right) \tag{8}$$

$$\frac{F_{z_{aero}}}{m} = \frac{Sq}{m} \left(C_z + \bar{Q} C_{z_q} + \delta it C_{z_{\delta it}}\right) \tag{9}$$

The body axes forces (Eqn. 7-9) can then be resolved into forces along the stability axes. Thrust (assumed to be in the X-direction only) and the force of gravity are also inserted.

$$\frac{F_{x_s}}{m} = \left[\frac{T}{m} - g \sin\theta + \frac{F_{x_{aero}}}{m}\right] \cos\alpha + \left[g \cos\theta\cos\phi + \frac{F_{z_{aero}}}{m}\right] \sin\alpha \tag{10}$$

$$\frac{F_{y_s}}{m} = g \cos\theta \sin\phi + \frac{F_{y_{aero}}}{m} \tag{11}$$

$$\frac{F_{z_s}}{m} = -\left[\frac{T}{m} - g \sin\theta + \frac{F_{x_{aero}}}{m}\right] \sin\alpha + \left[g \cos\theta\cos\phi + \frac{F_{z_{aero}}}{m}\right] \cos\alpha \tag{12}$$

The final transformation of forces from the stability axes to wind axes can then be made (Eqn. 13-15).

$$\frac{F_{x_w}}{m} = \frac{F_{x_s}}{m} \cos\beta + \frac{F_{y_s}}{m} \sin\beta \tag{13}$$

$$\frac{F_{y_w}}{m} = - \frac{F_{x_s}}{m} \sin\beta + \frac{F_{y_s}}{m} \cos\beta \tag{14}$$

$$\frac{F_{z_w}}{m} = \frac{F_{z_s}}{m} \tag{15}$$

The translational equations of motion can now be found by solving for the derivatives.

$$\dot{V} = \frac{F_{x_w}}{m} \tag{16}$$

$$-\dot{\alpha} = \frac{-F_{z_w}}{mV \cos\beta} + \frac{P_s \sin\beta}{\cos\beta} - Q_s \tag{17}$$

$$-\dot{\beta} = \frac{-F_{x_w}}{mV} + R_s \tag{18}$$

The Euler angular rates are also solved now (Eqn. 19-21).

$$-\dot{\psi} = - \frac{(R \cos\phi + Q \sin\phi)}{\cos\theta} \tag{19}$$

$$-\dot{\theta} = -Q \cos\phi + R \sin\phi \tag{20}$$

$$-\dot{\phi} = -P + \dot{\psi} \sin\theta \tag{21}$$

Next the moment equations about the body axes are solved for as shown below.

$$\frac{L}{I_{xx}} = \frac{Sqb}{I_{xx}} (C_l + \bar{P}C_{l_p} + \bar{R}C_{l_r} + \delta aC_{l_{\delta a}} + \delta rC_{l_{\delta r}}) \tag{22}$$

$$\frac{M}{I_{yy}} = \frac{Sq\bar{c}}{I_{yy}} (C_m + QC_{m_q} + \delta itC_{m_{\delta it}}) \tag{23}$$

$$\frac{N}{I_{zz}} = \frac{Sqb}{I_{zz}} (C_n + \bar{P}C_{n_p} + \bar{R}C_{n_r} + \delta aC_{n_{\delta a}} + \delta rC_{n_{\delta r}}) \tag{24}$$

The rotational equations of motion can now be written (Eqn. 25-27).

$$\dot{P} = \frac{(I_{yy} - I_{zz})}{I_{xx}} QR + \frac{I_{xz}(\dot{R}+PQ)}{I_{xx}} + \frac{L}{I_{xx}} \tag{25}$$

$$\dot{Q} = \frac{(I_{zz} - I_{xx})}{I_{yy}} RP + \frac{I_{xz}(R^2-P^2)}{I_{yy}} + \frac{M}{I_{yy}} \tag{26}$$

$$\dot{R} = \frac{(I_{xx} - I_{yy})}{I_{zz}} PQ + \frac{I_{xz}(\dot{P}-QR)}{I_{zz}} + \frac{N}{I_{zz}} \tag{27}$$

In the development of the velocities in the inertial frame, a small angle approximation was not used due to the fact that large angles are frequently encountered during the spin problem. The resulting equations are as follows:

$$\dot{S}_x = V\Big[\cos\alpha\cos\beta\cos\theta\cos\psi + \sin\beta(-\cos\phi\sin\psi + \sin\phi\sin\theta\cos\psi) + \sin\alpha\cos\beta\ (\sin\phi\sin\psi + \cos\phi\sin\theta\cos\psi)\Big] \tag{28}$$

$$\dot{S}_y = V\Big[\cos\alpha\cos\beta\cos\theta\sin\psi + \sin\beta(\cos\phi\cos\psi+\sin\phi\sin\theta\sin\psi) + \sin\alpha\sin\beta(\sin\phi\cos\psi + \cos\phi\sin\theta\sin\psi)\Big] \tag{29}$$

$$\dot{S}_z = V\Big[-\cos\alpha\cos\beta\sin\theta + \sin\beta(\sin\phi\cos\theta) + \sin\alpha\cos\beta(\cos\theta\cos\phi)\Big] \tag{30}$$

Integration of the various derivatives derived in the above equations yields the desired state variables.

IV. GRAPHICS

A. GRAPHICS PRESENTATION

The need for a good graphics presentation was evident due to the complete lack of any physical and audible cues to the pilot. Therefore a graphics display had to be generated which would give a representation of the earth's surface and provide the pilot with enough visual cues to enable him to orient himself throughout the problem. The essential visual cues needed for the pilot's orientation were indications of roll, pitch and yaw. A horizon was included for the orientation in pitch and roll. Due to the continuous yawing motion of an aircraft during a spin, it was vital to have a graphics picture that would accurately display this motion. After investigation of several possibilities, it was concluded that a grid system, attached to the earth's surface, composed of a one mile per side squares would provide the necessary requirements. The entire grid system was limited to six squares per side to avoid excessive computational time. By extending the grid lines at all four cardinal headings, the visual representation of the yawing motion of the aircraft was further enhanced. This improvement was accomplished by the fact that during a continuous yaw the pilot only sees a series of lines every 90 degrees. He is thus able to positively determine the yaw direction as well as a relative measure of the yaw rate. These extensions of

the grid lines also assist in the orientation of pitch and roll. This grid system is shown in Figure 3.

To provide the pilot with another source of visual cues, a single instrument was constructed. This instrument provided the pilot with two sources of information. The first was a "needle" providing the pilot with the aircraft's angle of bank and the second was a "ball" providing the pilot with a measure of the aircraft's sideslip angle. This instrument was not the normal "needle-ball" found on all Naval aircraft but was a combination of an attitude gyro and turn and bank indicator. It was felt that the angle of bank information taken from the attitude gyro combined with the sideslip angle information taken from the turn and bank indicator provided the pilot with the best information in the limited space available.

In the final display, the picture that the pilot saw was restricted in direction to the X-axis of the aircraft and to a square with a field of view angular limit of plus or minus 18.5 degrees. Within this square or window lies the horizon and portions of the grid reference system. As the aircraft maneuvers in space the horizon and grid reference system move dynamically within this window creating the sensation of flight. The complete initial display is pictured in Figure 4.

B. GRAPHICS PROCESSING

The processing of the grid reference system from a three-dimensional object to a two-dimensional plane capable of

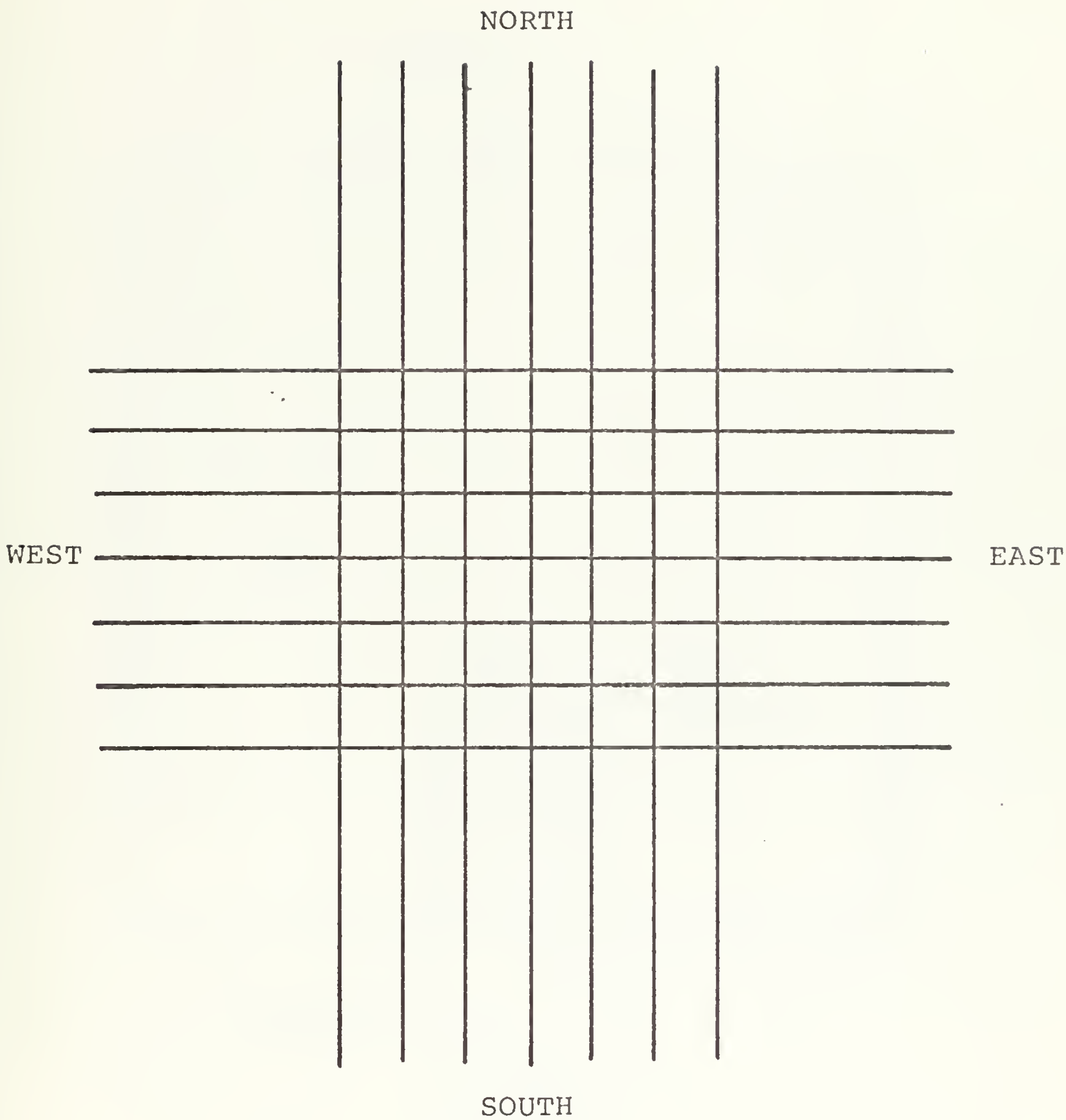
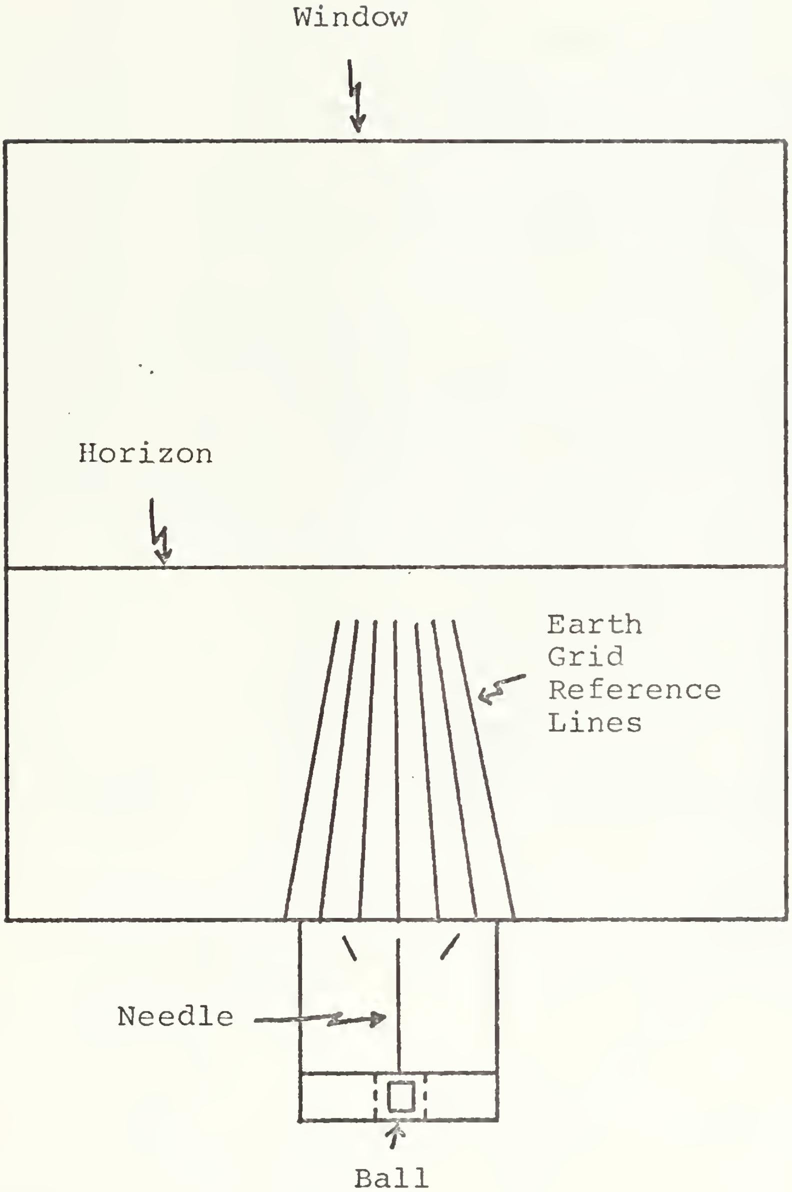


Figure 3. Earth Grid Reference Lines.



(Initial position - 30,000 ft. above and 6000 ft. south of center of grid--looking north)

Figure 4. Initial Graphics Display.

being displayed on a screen proved to be the most complicated portion of the display. The same system developed by L. G. Roberts [Ref. 3] and R. B. Desens [Ref. 4] and used by J. H. Kahrs [Ref. 1] was used here. It basically consists of the construction of a single transformation matrix for all display points. Two coordinate systems were used in the development of this matrix, that of the earth reference system (object) and that of the aircraft (viewing plane), and are shown in Figure 5.

The transformation matrix (H-Matrix) is the product of five matrices: rotation, translation, perspective, scale, and another translation. The H-Matrix is further reduced

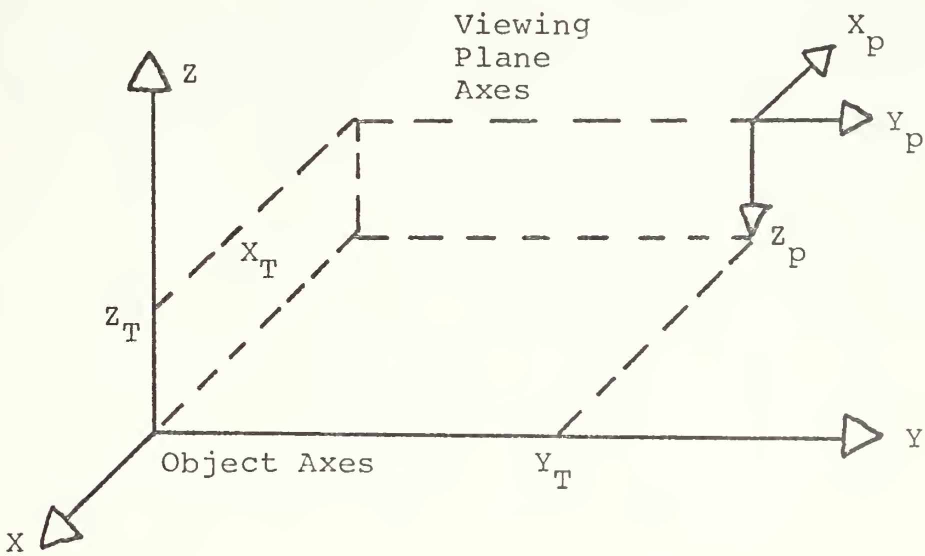


Figure 5. Graphic Coordinate System.

by Desens to the product of three matrices as shown in Figure 6.

$$H = \begin{bmatrix} A_1 & A_2 & A_3 & 0 \\ B_1 & B_2 & B_3 & 0 \\ C_1 & C_2 & C_3 & 0 \\ X_T & Y_T & Z_T & 1 \end{bmatrix} \begin{bmatrix} AA_1 & AA_2 & AA_3 & 0 \\ BB_1 & BB_2 & BB_3 & 0 \\ CC_1 & CC_2 & CC_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & -Y_o/F & -Z_o/F & -S/F \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & Y_o & Z_o & S \end{bmatrix}$$

Object Axis Rotation Viewing Plane Translation	Viewing Plane Orientation	Perspective Scale Offset

Figure 6. H-Matrix.

The first matrix consists of the direction cosines of the Euler angle rotation of the object axes and the translation distances between the two axes system. The direction cosines and the order of rotation are shown in Figure 7.

Since the object axes in this problem was a fixed earth reference system, the direction cosines are all zero except for the diagonal terms which have a value of one. The matrix then is simply reduced to a viewing plane translation. The translation distances; X_T, Y_T and Z_T are derived as follows:

$$X_T = X_{\text{object}} - X_{\text{view plane}}$$

$$Y_T = Y_{\text{object}} - Y_{\text{view plane}}$$

$$Z_T = Z_{\text{object}} - Z_{\text{view plane}}$$

$A_1 = \cos\beta\cos\alpha$

$A_2 = \cos\beta\sin\alpha$

$A_3 = -\sin\beta$

$B_1 = -\cos\gamma\sin\alpha + \sin\gamma\sin\beta\cos\alpha$

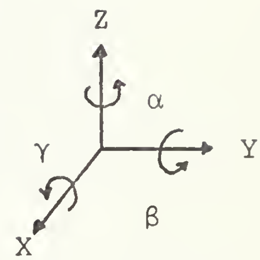
$B_2 = \cos\alpha\cos\gamma + \sin\gamma\sin\beta\sin\alpha$

$B_3 = \sin\gamma\cos\beta$

$C_1 = \sin\gamma\sin\alpha + \cos\gamma\sin\beta\cos\alpha$

$C_2 = -\sin\gamma\cos\alpha + \cos\gamma\sin\beta\sin\alpha$

$C_3 = \cos\beta\cos\gamma$



Order of rotation α,β,γ

Figure 7. Euler Angle Rotation.

The second matrix is composed of the direction cosines of the Euler angles of the aircraft or viewing plane axes and are listed below.

$AA_1 = \cos\psi\cos\theta$

$AA_2 = \sin\psi\cos\phi - \cos\psi\sin\theta\sin\phi$

$AA_3 = \sin\psi\sin\phi + \cos\psi\sin\theta\cos\phi$

$BB_1 = -\cos\theta\sin\psi$

$BB_2 = \cos\psi\cos\phi - \sin\theta\sin\psi\sin\phi$

$BB_3 = \cos\psi\sin\phi - \sin\psi\sin\theta\cos\phi$

$CC_1 = -\sin\theta$

$CC_2 = -\cos\theta\sin\phi$

$CC_3 = \cos\theta\cos\phi$

Order of rotation

ψ(yaw), θ(pitch), ϕ(roll)

The third matrix is composed of the offset option, Z_o and Y_o, the scale factor (S) and the focal length(F). The offset option was not used but its usage is explained in Ref. 4. The scale factor was set at 1/2 and the focal length, the distance between viewer and the viewing plane, was set at 1.5 ft.

To process the grid reference system or object, a point (X,Y,Z) is taken and converted to homogeneous coordinates by the addition of a scale factor (W). This yields new coordinates (X',Y',Z',W) where X' = WX, Y' = WY, Z' = WZ. Post multiplying these coordinates by the H-Matrix yields (X",Y",Z",W'). The display coordinates can now be found by dividing by W'.

$Y = Y''/W'$

$Z = Z''/W'$

The X-coordinate was not used in this display since it is only an indication of depth. The final display coordinates are obtained by passing each point of the grid reference system through the H-Matrix.

The horizon was constructed by drawing a line parallel to the Y-object axis and offset a distance in the negative X-direction. The Z-coordinate was set to zero. In doing so

the assumption was made that the earth was flat and therefore did not account for the fact that when flying at an altitude a depression angle is created due to the curvature of the earth. This assumption was valid since the horizon was only used for a relative measure of orientation for the pilot and not as a measure of the altitude of the aircraft. The coordinates of the horizon are passed through a modified viewing plane orientation matrix to account for pitch and roll of the aircraft. The yaw angle of the aircraft is set to zero since it does not have any apparent visual influence on the movement of the horizon. This results in the following matrix.

$$AA_1 = \cos\theta$$

$$AA_2 = -\sin\theta\sin\phi$$

$$AA_3 = \sin\theta\cos\phi$$

$$BB_1 = 0$$

$$BB_2 = \cos\phi$$

$$BB_3 = \sin\phi$$

$$CC_1 = -\sin\theta$$

$$CC_2 - \cos\theta\sin\phi$$

$$CC_3 = \cos\theta\cos\phi$$

V. RESULTS OF SPIN TESTS

Several spin tests were conducted in order to compare these results with the results of other simulators using the same aircraft parameters and aerodynamic coefficients. The aircraft parameters and aerodynamic coefficients used in all tests were obtained from W. P. Gilbert [Ref. 5] and are representative of a variable-sweep fighter aircraft. A wing-sweep angle of 16° was the only configuration considered during the tests.

In all cases the aircraft was initially positioned at an altitude of 30,000 feet and an airspeed of 622 ft/sec. The spin was entered by reducing the throttle to the idle position followed by movement of the horizontal stabilator to the full trailing edge up, rudder to full trailing edge left, and the ailerons to full right wing down. The controls were maintained in these positions until the spin had fully developed when they were then released to the neutral position. The resulting spin was limited in altitude to 10,000 feet or until the spin development was such that the limits of the computer were exceeded. At no time was an attempt made to effect a recovery.

The resulting aircraft motion was a stall exhibiting unstable flight characteristics in lateral control. A right or left roll of 360° at high angles of attack then ensued after which the aircraft entered a fast flat-spin. During

the spin, the average angle of attack was 80° with a yaw rate of about -133 deg/sec. The pitch angle and roll angle remained relatively constant throughout the spin at approximately -15° and 0° respectively. At the end of 60 seconds, the aircraft had completed 9.5 turns and lost about 7000 feet of altitude. The final aircraft velocity was 262 ft/sec. A complete time history of the results of one of the spin tests is shown in Figure 8. A brief comparison with the results obtained by Gilbert is shown below. A complete time history of Gilbert's results is shown in Figure 9.

	Simulator	Gilbert
1. Average α	80°	83°
2. Yaw Rate	-133 deg/sec	-160 deg/sec
3. Average θ	-15°	-12°
4. Average ϕ	0°	0°
5. Number Turns	11	10
6. Altitude Lost	7000 feet	8000 feet
7. Length of Spin	60 sec	40 sec

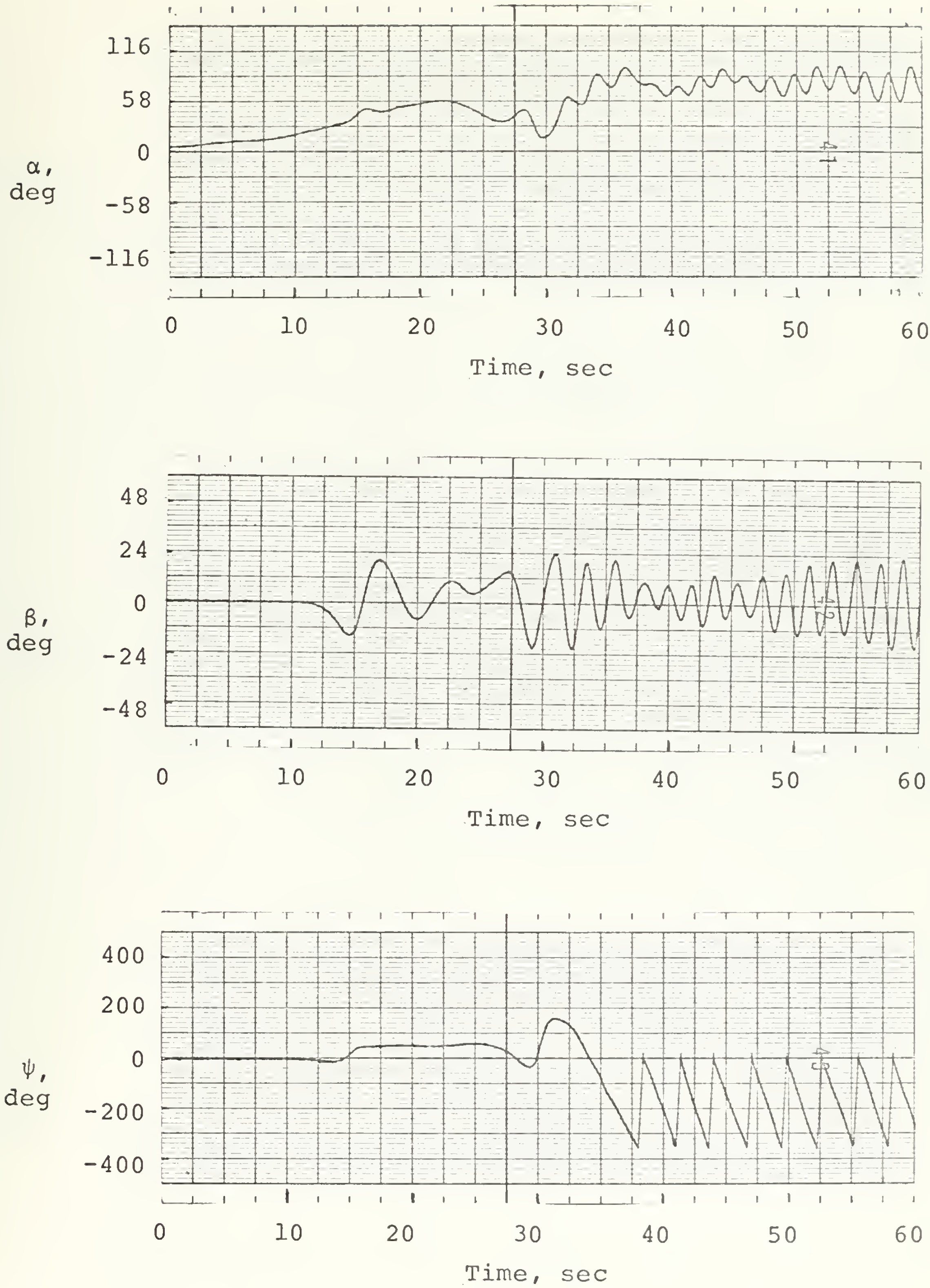


Figure 8. Results of Spin Test.

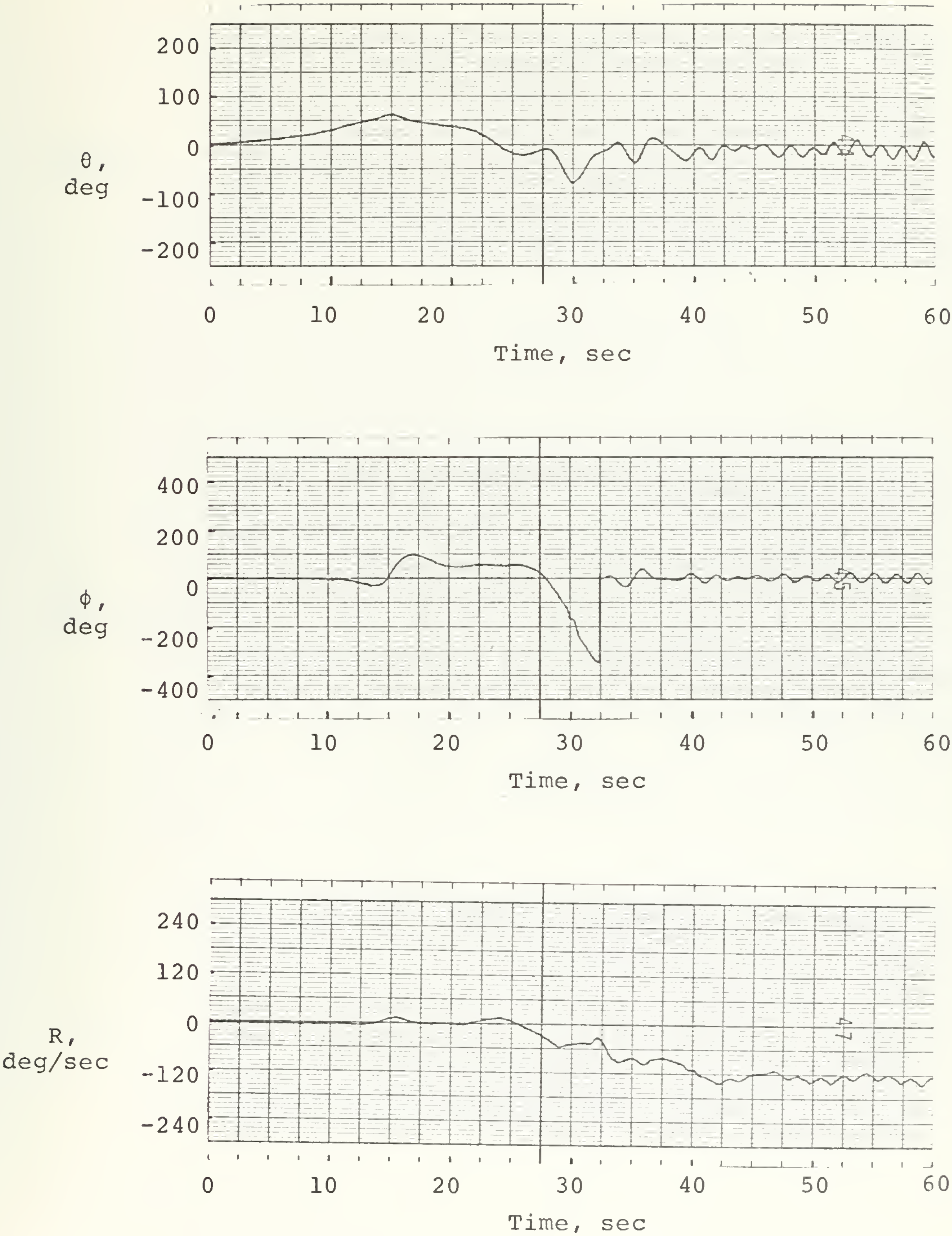


Figure 8. (Continued).

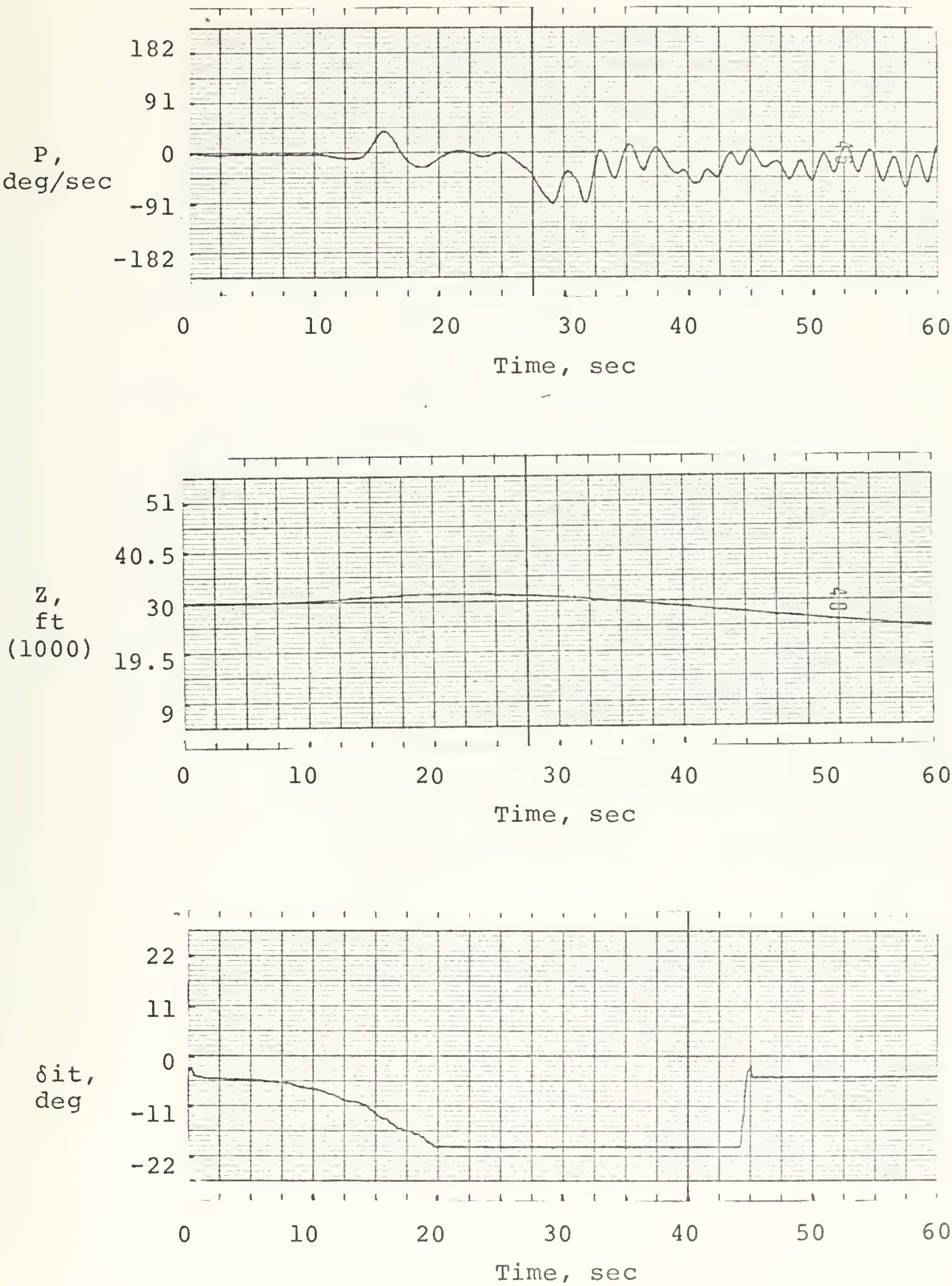
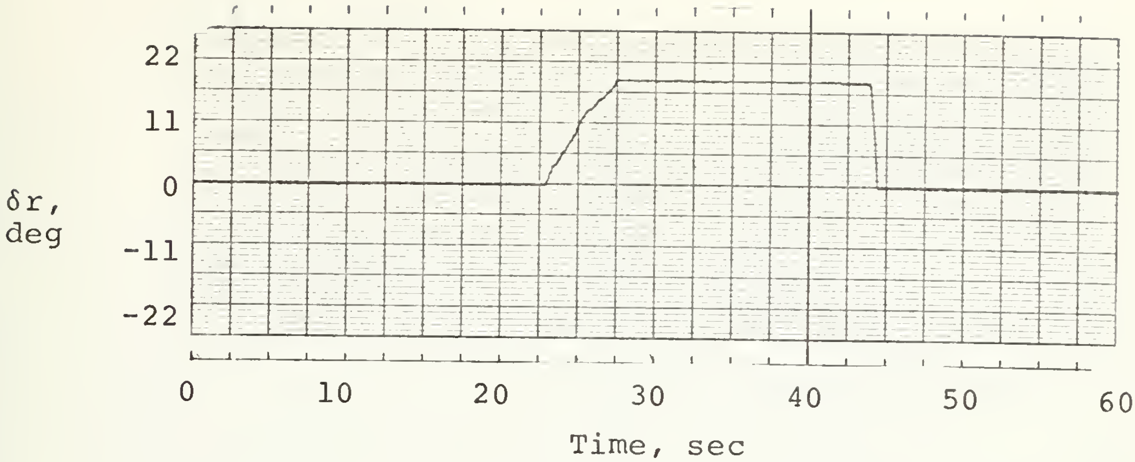


Figure 8. (Continued).



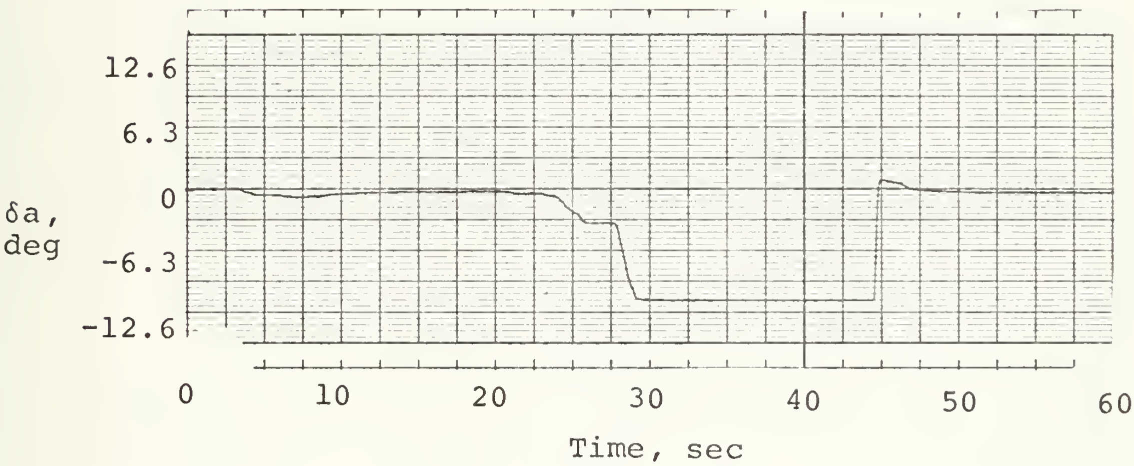


Figure 8. (Continued).

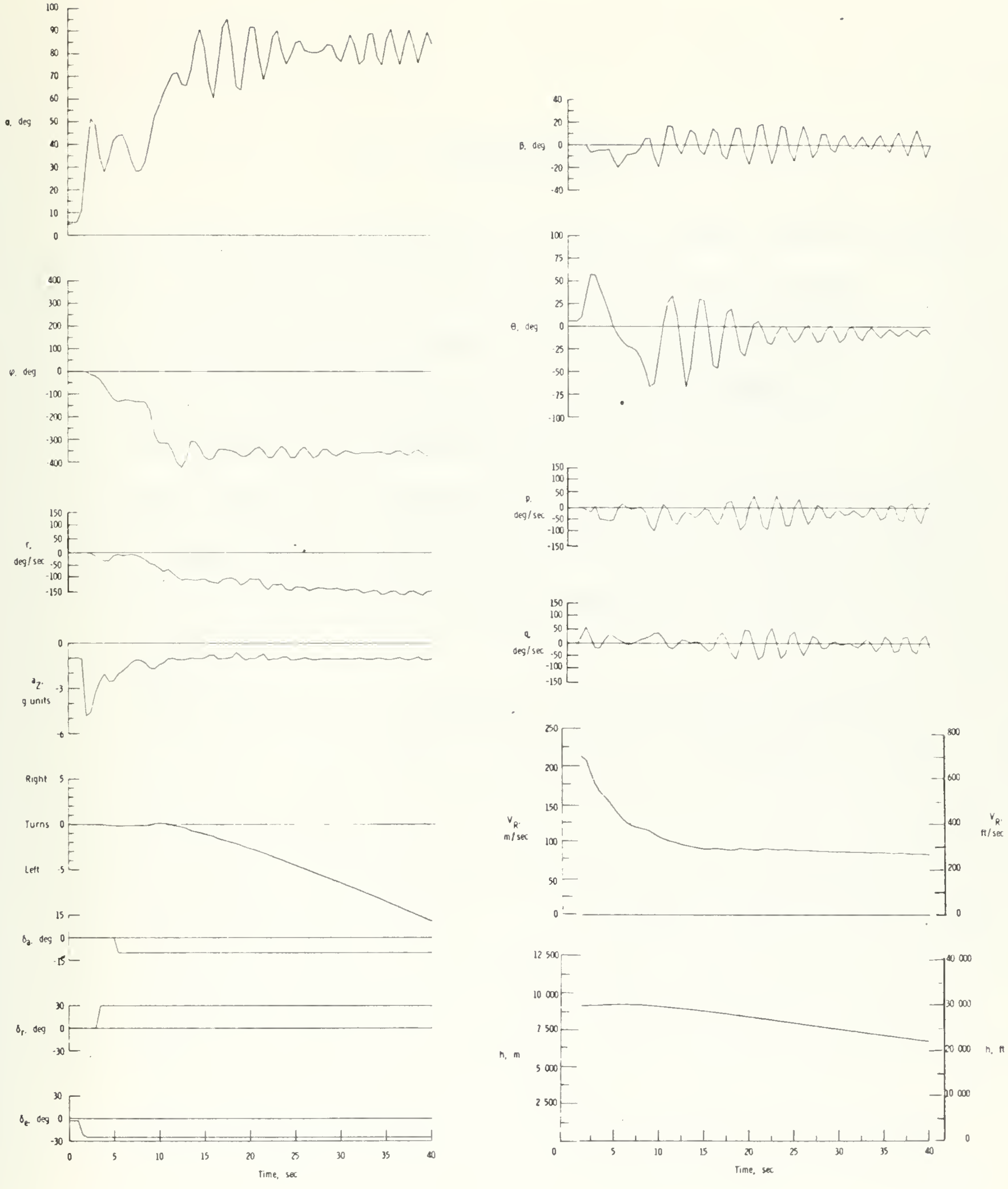


Figure 9. Representative Spin Results.

VI. CONCLUSIONS

As a result of conducting a series of spin tests on this simulator the following conclusions have been reached:

1. The simulator provided excellent visual cues to enable experienced pilots to orient themselves throughout the entire problem.
2. The simulator exhibited good dynamic response with a computational loop time of 80 milliseconds and solution update rate of approximately 16 samples per second.
3. The simulator was capable of providing meaningful spin data from which comparisons and further study could be made.
4. One minor drawback to the simulator was the lack of any physical cues, i.e. "g" forces. These forces can be significant in an actual spin and severely restrict the pilot's movement. Lack of these forces has led to pilots over-controlling the simulator and thereby risking the possibility of introducing erroneous information or exceeding the limits of the computer.
5. The versatility of the simulator, in the ease with which the aircraft or aircraft parameters may be changed, has made it a valuable research tool and source for further study in the field of flight dynamics.

APPENDIX A

THE DIGITAL PROGRAM

This appendix contains a listing of the computer program written in the FORTRAN language. It consists of a main program and three subprograms: the data reduction, the computation loop, and the A/D-D/A. The A/D-D/A subroutine is written in METASYMBOL, the assembly language for the XDS-9300, and was prepared by the computer laboratory staff.

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                    FIXED BASE SPIN SIMULATOR                        *
*                               BY                                    *
*                         LT B.H. KENTON                              *
*                              AND                                    *
*                        LTJG M.H. REDLIN                             *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                          MAIN PROGRAM                               *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      COMMON COEFAB(15,19,9),COEFA(16:24,19),TRIG(361),IDIR(3),ITDIR(20)
     X,NUM,SF1,SF2,SF3,SF4,SF5,SF6,SF7,SF14,SF15,SF16,SF17,SF18,SF19,SF2
     X0,SF21,SF22,SF23,SF24,SF25,SF26,SF27,SF28,SF29,SF30,SF31,SF32,SF33
     X,TRIGC(361),B,CB,SF34,SF35,SF36,SF37,SF38,SF39,SF40,IDEV,SZF,SF8,S
     XF9,SF10,SF11,SF12
   15 CALL INITIAL
      CALL LOOPER
      IF(NUM.EQ.1) GO TO 15
      STOP
      END
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                         *
*                      DATA REDUCTION SUBROUTINE                          *
*                                                                         *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                         *
*     DIMENSION - EQUIVALENCE - DATA - COMMON STATEMENTS                  *
*                                                                         *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      SUBROUTINE INITIAL
      DIMENSION ITEX1(3),ITEX2(4),ITEX3(1),ITEX4(4),ITEX5(1),ITEX6(4),IT
     XEX7(5),ITEX8(7),ITEX9(4),POT(0:53),DEGA(19),DEGB(9),KK(4),KPOT(42)
      COMMON COEFAB(15,19,9),COEFA(16:24,19),TRIG(361),IDIR(3),ITDIR(20)
     X,NUM,SF1,SF2,SF3,SF4,SF5,SF6,SF7,SF14,SF15,SF16,SF17,SF18,SF19,SF2
     X0,SF21,SF22,SF23,SF24,SF25,SF26,SF27,SF28,SF29,SF30,SF31,SF32,SF33
     X,TRIGC(361),B,CB,SF34,SF35,SF36,SF37,SF38,SF39,SF40,IDEV,SZF,SF8,S
     XF9,SF10,SF11,SF12
      DATA DEGB/-40.,-30.,-20.,-10.,0.0,10.,20.,30.,40./,DEGA/0.0,5.,10.
     X,15.,20.,25.,30.,35.,40.,45.,50.,55.,60.,65.,70.,75.,80.,85.,90./,
     XKK/16,20,21,24/,KPOT/0,25,1,26,2,27,3,30,4,31,5,32,6,33,7,34,10,35
     X,11,36,12,37,13,40,14,41,15,42,16,43,17,44,20,45,21,46,22,50,23,52
     X,24,53/
    1 FORMAT(I1)
    6 FORMAT(I2)
   51 FORMAT(2F10.0)
  103 FORMAT(I2,2X,I1,5X,7F10.7/8F10.7/4F10.7)
  104 FORMAT(I2,8X,7F10.7/8F10.7/4F10.7)
  105 FORMAT(I2,1X,7F11.7/7F11.7/5F11.7)
  107 FORMAT('1',' ')
  108 FORMAT(8F10.0)
  110 FORMAT(6F10.2)
  111 FORMAT(8F10.2/8F10.2/3F10.2)
  120 FORMAT('0',20X,'A000 INDICATES -PDOT/',F5.2,4X,
     X'A001 INDICATES +P/',F5.2,7X,
     X'A002 INDICATES -QDOT/',F5.2,//,21X,
```

```
     X'A055 INDICATES +Q/',F5.2,7X,
     X'A006 INDICATES -RDØT/',F5.2,4X,
     X'A007 INDICATES +R/',F5.2,//,21X,
     X'A015 INDICATES +T/RMASS/',F3.0,3X,
     X'A017 INDICATES -SX/',F6.0,5X,
     X'A051 INDICATES -SY/',F6.0,//,21X,
     X'A027 INDICATES -SZ/',F6.0,5X,
     X'A024 INDICATES DIT/',F3.0,8X,
     X'A025 INDICATES THETA/',F4.0,//,21X,
     X'A026 INDICATES DA/',F3.0,9X,
     X'A031 INDICATES BETA/',F3.0,7X,
     X'A033 INDICATES PHI/',F4.0,//,21X,
     X'A034 INDICATES QUE/',F6.2,5X,
     X'A035 INDICATES PSI/',F4.0,7X,
     X'A036 INDICATES VEL/',F5.0,//,21X,
     X'A041 INDICATES DR/',F3.0,9X,
     X'A045 INDICATES ALPHA/',F4.0,//)
 121 FØRMAT('0',20X,'T420 INDICATES VDØT/',F3.0,7X,
     X'T421 INDICATES -ALPHADØT/',F3.1,2X,
     X'T422 INDICATES -BETADØT/',F3.1,//,21X,
     X'T423 INDICATES -PSIDØT/',F3.1,4X,
     X'T424 INDICATES -THETADØT/',F3.1,2X,
     X'T425 INDICATES -PHIDØT/',F3.1,//,21X,
     X'T426 INDICATES ALI/',F4.2,7X,
     X'T427 INDICATES SXDØT/',F5.0,4X,
     X'T430 INDICATES SYDØT/',F5.0,//,21X,
     X'T431 INDICATES SZDØT/',F5.0,4X,
     X'T432 INDICATES AMI/',F4.2,7X,
     X'T433 INDICATES ANI/',F5.2)
 122 FØRMAT(' ',20X,'THE ØUTPUTS ØF THE AMPLIFIERS ARE REPRESENTATIVE Ø
     XF THE FØLLØWING SCALED VARIABLES:')
 123 FØRMAT(' ',20X,'THE D/A TRUNKS REPRESENT THE FØLLØWING SCALED VARI
     XABLES:')
 130 FØRMAT('FIXED BASE  ')
 131 FØRMAT('SPIN SIMULATØR  ')
```

```
132 FØRMAT('BY  ')
133 FØRMAT('LT B.H. KENTØN  ')
134 FØRMAT('AND ')
135 FØRMAT('LTJG M.H. REDLIN')
136 FØRMAT('ASST PRØF AERØ ENG  ')
137 FØRMAT('NAVAL PØSTGRADUATE SCHØØL    ')
138 FØRMAT('SEPTEMBER 1972  ')
700 FØRMAT('0',50X,'CØEFFICIENT NUMBER ',I2,//)
701 FØRMAT(' ',7X,'BETA',3X,9(F5.1,7X))
702 FØRMAT(' ',6X,'ALPHA',/)
703 FØRMAT('0',6X,F5.1,9(1X,F11.7))
704 FØRMAT(' ',29X,5('CØEFFICIENT',4X))
705 FØRMAT(' ',31X,5('NUMBER',9X))
706 FØRMAT(' ',20X,'ALPHA',8X,5(I2,13X),/)
707 FØRMAT('0',20X,F5.1,2X,5(F12.7,3X))
708 FØRMAT(' ',29X,4('CØEFFICIENT',4X))
709 FØRMAT(' ',31X,4('NUMBER',9X))
760 FØRMAT(' ',11X,'ØRIGINAL CØEF ARRAY')
761 FØRMAT(' ',7X,'USABLE CØEF ARRAY')
762 FØRMAT(' ',25X,'ØRIGINAL CØEF ARRAYS',/)
763 FØRMAT(' ',25X,'USABLE CØEF ARRAYS',/)
780 FØRMAT(' ',/////)
781 FØRMAT(' ',40X,'SF1  = ',F10.3,20X,'SF30 = ',F10.3,/,
   X41X,'SF2  = ',F10.3,20X,'SF31 = ',F10.3,/,
   X41X,'SF3  = ',F10.3,20X,'SF32 = ',F10.3,/,
   X41X,'SF4  = ',F10.3,20X,'SF33 = ',F10.3,/,
   X41X,'SF5  = ',F10.3,20X,'SF34 = ',F10.3,/,
   X41X,'SF6  = ',F10.3,20X,'SF35 = ',F10.3,/,
   X41X,'SF7  = ',F10.3,20X,'SF36 = ',F10.3,/,
   X41X,'SF8  = ',F10.3,20X,'SF37 = ',F10.3,/,
   X41X,'SF9  = ',F10.3,20X,'SF38 = ',F10.3,/,
   X41X,'SF10 = ',F10.3,20X,'SF39 = ',F10.3,/,
   X41X,'SF11 = ',F10.3,20X,'SF40 = ',F10.3,/,
   X41X,'SF12 = ',F10.3,/,
   X41X,'SF13 = ',F10.3,20X,'SX0  = ',F10.3,/,
```

```
     X41X,'SF14 = ',F10.3,20X,'SZO  = ',F10.3,/,
     X41X,'SF15 = ',F10.3,20X,'VO   = ',F10.3,/,
     X41X,'SF16 = ',F10.3,20X,'A10  = ',F10.3,/,
     X41X,'SF17 = ',F10.3,20X,'DITO = ',F10.3,/,
     X41X,'SF18 = ',F10.3,20X,'RHO  = ',F10.5,/,
     X41X,'SF19 = ',F10.3,/,
     X41X,'SF20 = ',F10.3,/,
     X41X,'SF21 = ',F10.3,20X,'W    = ',F10.3,/,
     X41X,'SF22 = ',F10.3,20X,'B    = ',F10.3,/,
     X41X,'SF23 = ',F10.3,20X,'CB   = ',F10.3,/,
     X41X,'SF24 = ',F10.3,20X,'S    = ',F10.3,/,
     X41X,'SF25 = ',F10.3,20X,'RIXX = ',F10.3,/,
     X41X,'SF26 = ',F10.3,20X,'RIYY = ',F10.3,/,
     X41X,'SF27 = ',F10.3,20X,'RIZZ = ',F10.3,/,
     X41X,'SF28 = ',F10.3,20X,'RIXZ = ',F10.3,/,
     X41X,'SF29 = ',F10.3,20X,'T    = ',F10.3,/,
     X41X,'SZF  = ',F10.3)
8001 FORMAT(' ',40X,'POT(',I1,')  = ',F6.5,20X,'POT(',I2,') = ',F6.5)
8002 FORMAT(' ',40X,'POT(',I2,') = ',F6.5,20X,'POT(',I2,') = ',F6.5)
9000 FORMAT(' ',40X,'POT SETTINGS',//)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*    TITLE PAGE                                                       *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  10 OUTPUT(101)'INPUT AGT NUMBER'
     READ(101,1)IDEV
     IF((IDEV.NE.1).AND.(IDEV.NE.2)) GO TO 10
     CALL DGINIT(IDEV,IDIR,3,IER)
     CALL DTINIT(IDEV,ITDIR,20,IER)
     ENCODE(12,130,ITEX1)
     ENCODE(16,131,ITEX2)
     ENCODE(4,132,ITEX3)
     ENCODE(16,133,ITEX4)
     ENCODE(4,134,ITEX5)
```

```
      ENCØDE(16,135,ITEX6)
      ENCØDE(20,136,ITEX7)
      ENCØDE(28,137,ITEX8)
      ENCØDE(16,138,ITEX9)
      CALL TEXTØ(IDEV,ITEX1,3,4,33,3,3,IER)
      CALL TEXTØ(IDEV,ITEX2,4,9,27,3,3,IER)
      CALL TEXTØ(IDEV,ITEX3,1,14,46,2,3,IER)
      CALL TEXTØ(IDEV,ITEX4,4,17,27,3,3,IER)
      CALL TEXTØ(IDEV,ITEX5,1,20,45,2,3,IER)
      CALL TEXTØ(IDEV,ITEX6,4,23,24,3,3,IER)
      CALL TEXTØ(IDEV,ITEX7,5,26,30,2,3,IER)
      CALL TEXTØ(IDEV,ITEX8,7,32,24,2,3,IER)
      CALL TEXTØ(IDEV,ITEX9,4,36,34,2,3,IER)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                  READ AND CØMPUTE SCALE FACTØRS                     *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      READ(5,111) SF1,SF2,SF3,SF4,SF5,SF6,SF8,SF9,SF10,SF11,SF12,SF13,
     1SF14,SF15,SF16,SF17,SF18,SF19,SF30
      READ(5,110) SXO,SZO,VO,A10,DITO,RHØ
      READ(5,108)W,B,CB,S,RIXX,RIYY,RIZZ,RIXZ
      READ(5,51)T,SZF
      CØN1=57.29577
      RMASS=W/32.2
      ISF7=T/(RMASS*10.)+1.0
      SF7=ISF7*10
      SF20=SF1*SF1/(2.*SF19)
      SF21=SF6/SF4
      SF22=SF1/SF4
      SF23=SF1/SF5
      SF24=SF1/SF6
      SF25=SF4/SF5
      SF26=SF5/SF6
      SF27=SF4*SF4
```

```
      SF28=SF5*SF5
      SF29=SF6*SF6
      SF31=SF7/(SF1*SF5)
      SF32=SF7/(SF1*SF6)
      SF33=SF1/SF2
      SF34=SF1/SF3
      SF35=C0N1*SF5/SF8
      SF36=C0N1*SF6/SF9
      SF37=C0N1*SF6/SF10
      SF38=C0N1*SF6/SF11
      SF39=C0N1*SF6/SF12
      SF40=SF7/SF1
      IF(TEST(7).GT.0) G0 T0 20
      WRITE(6,107)
      WRITE(6,780)
      WRITE(6,781)SF1,SF30,SF2,SF31,SF3,SF32,SF4,SF33,SF5,SF34,SF6,SF35,
     XSF7,SF36,SF8,SF37,SF9,SF38,SF10,SF39,SF11,SF40,SF12,SF13,SX0,
     XSF14,SZ0,SF15,V0,SF16,A10,SF17,DIT0,SF18,RH0,SF19,SF20,SF21,
     XW,SF22,B,SF23,CB,SF24,S,SF25,RIXX,SF26,RIYY,SF27,RIZZ,SF28,
     XRIXZ,SF29,T,SZF
* * * * * * * * * * * * * * * * * ** * * * * * * * * * * * * * * * * *
*                                                                     *
*                          BUILD TRIG TABLE                           *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
   20 D0 230 I=1,361
      TRIG(I)=SIN((I-181.0)/C0N1)
      TRIGC(I)=C0S((I-181.0)/C0N1)
  230 C0NTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                    READ AIRCRAFT C0EFFICIENTS                       *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      D0 200 J=1,135
```

```
      READ(5,103)I,IB,(COEFAB(I,IA,IB),IA=1,19)
  200 CONTINUE
      DO 220 J=1,6
      READ(5,104) I,(COEFA(I,IA),IA=1,19)
  220 CONTINUE
      DO 221 J=1,3
      READ(5,105) I,(COEFA(I,IA),IA=1,19)
  221 CONTINUE
      IF(TEST(7).GT.0) GO TO 21
      WRITE(6,107)
      WRITE(6,780)
      DO 720 I=1,15
      WRITE(6,760)
      WRITE(6,700)I
      WRITE(6,701)(DEGB(J),J=1,9)
      WRITE(6,702)
      DO 719 IA=1,19
      WRITE(6,703)DEGA(IA),(COEFAB(I,IA,IB),IB=1,9)
  719 CONTINUE
      WRITE(6,107)
      WRITE(6,780)
  720 CONTINUE
      DO 721 I=1,3,2
      IPLS=I+1
      WRITE(6,762)
      IF(I.GT.1) GO TO 724
      WRITE(6,704)
      WRITE(6,705)
      GO TO 723
  724 WRITE(6,708)
      WRITE(6,709)
  723 WRITE(6,706)(J,J=KK(I),KK(IPLS))
      DO 722 IA=1,19
      WRITE(6,707) DEGA(IA),(COEFA(J,IA),J=KK(I),KK(IPLS))
  722 CONTINUE
```

```
      WRITE(6,107)
      WRITE(6,780)
  721 CONTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                      *
*                COMPUTE USEABLE AIRCRAFT COEFFICIENTS                 *
*                                                                      *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
   21 DO 5001 IB=1,9
      DO 5002 IA=1,19
      COEFAB(1,IA,IB)=S*B*COEFAB(1,IA,IB)/RIXX*SF20/SF27
      COEFAB(2,IA,IB)=S*CB*COEFAB(2,IA,IB)/RIYY*SF20/SF28
      COEFAB(3,IA,IB)=S*B*COEFAB(3,IA,IB)/RIZZ*SF20/SF29
      COEFAB(4,IA,IB)=S*COEFAB(4,IA,IB)/RMASS*SF20/SF7
      COEFAB(5,IA,IB)=S*COEFAB(5,IA,IB)/RMASS*SF20/SF7
      COEFAB(6,IA,IB)=S*COEFAB(6,IA,IB)/RMASS*SF20/SF7
      COEFAB(7,IA,IB)=S*COEFAB(7,IA,IB)/RMASS*SF16*SF20/SF7
      COEFAB(8,IA,IB)=S*CB*COEFAB(8,IA,IB)/RIYY*SF16*SF20/SF28
      COEFAB(9,IA,IB)=S*COEFAB(9,IA,IB)/RMASS*SF18*SF20/SF7
      COEFAB(10,IA,IB)=S*B*COEFAB(10,IA,IB)/RIXX*SF18*SF20/SF27
      COEFAB(11,IA,IB)=S*B*COEFAB(11,IA,IB)/RIZZ*SF18*SF20/SF29
      COEFAB(12,IA,IB)=S*COEFAB(12,IA,IB)/RMASS*SF17*SF20/SF7
      COEFAB(13,IA,IB)=S*B*COEFAB(13,IA,IB)/RIXX*SF17*SF20/SF27
      COEFAB(14,IA,IB)=S*B*COEFAB(14,IA,IB)/RIZZ*SF17*SF20/SF29
      COEFAB(15,IA,IB)=S*COEFAB(15,IA,IB)/RMASS*SF16*SF20/SF7
 5002 CONTINUE
 5001 CONTINUE
      DO 5003 IA=1,19
      COEFA(16,IA)=S*COEFA(16,IA)/RMASS*SF20/(SF22*SF7)
      COEFA(17,IA)=S*B*COEFA(17,IA)/RIXX*SF20/(SF22*SF27)
      COEFA(18,IA)=S*B*COEFA(18,IA)/RIZZ*SF20/(SF22*SF29)
      COEFA(19,IA)=S*COEFA(19,IA)/RMASS*SF20/(SF24*SF7)
      COEFA(20,IA)=S*B*COEFA(20,IA)/RIXX*SF20/(SF24*SF27)
      COEFA(21,IA)=S*B*COEFA(21,IA)/RIZZ*SF20/(SF24*SF29)
      COEFA(22,IA)=S*COEFA(22,IA)/RMASS*SF20/(SF23*SF7)
```

```
      CØEFA(23,IA)=S*CB*CØEFA(23,IA)/RIYY*SF20/(SF23*SF28)
      CØEFA(24,IA)=S*CØEFA(24,IA)/RMASS*SF20/(SF23*SF7)
 5003 CØNTINUE
      IF(TEST(7).GT.0) GØ TØ 22
      DØ 750 I=1,15
      WRITE(6,761)
      WRITE(6,700)I
      WRITE(6,701)(DEGB(J),J=1,9)
      WRITE(6,702)
      DØ 749 IA=1,19
      WRITE(6,703)DEGA(IA),(CØEFAB(I,IA,IB),IB=1,9)
  749 CØNTINUE
      WRITE(6,107)
      WRITE(6,780)
  750 CØNTINUE
      DØ 751 I=1,3,2
      IPLS=I+1
      WRITE(6,763)
      IF(I.GT.1) GØ TØ 754
      WRITE(6,704)
      WRITE(6,705)
      GØ TØ 753
  754 WRITE(6,708)
      WRITE(6,709)
  753 WRITE(6,706)(J,J=KK(I),KK(IPLS))
      DØ 752 IA=1,19
      WRITE(6,707)DEGA(IA),(CØEFA(J,IA),J=KK(I),KK(IPLS))
  752 CØNTINUE
      WRITE(6,107)
      WRITE(6,780)
  751 CØNTINUE
   22 CØNTINUE
      CALL SETLINES(1,RIXZ,2,RIYY-RIZZ,3,RIZZ-RIXX,4,RIXX-RIYY)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                      *
```

```
*                                   SETPØT RØUTINE                                   *
*                                                                                    *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      PØT(0)=SF5*ABS(RIXZ)/RIXX/SF4
      PØT(1)=SF5*SF6/(10.*SF4)*ABS(RIYY-RIZZ)/RIXX/SF4
      PØT(2)=SF4/10.
      PØT(3)=SF4*SF4/SF5*ABS(RIXZ)/RIYY/SF5
      PØT(4)=SF4*SF6/(10.*SF5)*ABS(RIZZ-RIXX)/RIYY/SF5
      PØT(5)=SF5/10.
      PØT(6)=SF5*ABS(RIXZ)/RIZZ/SF6
      PØT(7)=SF4*SF5/(10.*SF6)*ABS(RIXX-RIYY)/RIZZ/SF6
      PØT(10)=SF6/10.
      PØT(11)=.1*SF4/(SF5*SF6)*SF4
      PØT(12)=.1*SF6/(SF4*SF5)*SF6
      PØT(13)=.3270
      PØT(14)=T/RMASS/SF7/10./.3166
      PØT(15)=.0260
      PØT(16)=ABS(SX0)/SF13
      PØT(17)=.5000
      PØT(20)=ABS(SZ0)/SF15
      PØT(21)=SF1/SF13
      PØT(22)=SF2/SF14
      PØT(23)=SF3/SF15
      PØT(24)=.1*180./3.1416*SF6/SF11
      PØT(25)=.1*180./3.1416*SF5/SF8
      PØT(26)=.1*180./3.1416*SF6/SF9
      PØT(27)=.1*180./3.1416*SF6/SF12
      PØT(30)=.1*180./3.1416*SF6/SF10
      PØT(31)=SF7/SF1
      PØT(32)=V0/SF1
      PØT(33)=RHØ*SF19
      PØT(34)=.1400
      PØT(35)=.1675
      PØT(36)=.0357
      PØT(37)=.2000
```

```
      PØT(40)=.0962
      PØT(41)=.2800
      PØT(42)=A10/SF8
      PØT(43)=.0820
      PØT(44)=ABS(DITO)/SF16
      PØT(45)=.1*SF6*SF6/(SF4*SF4)
      PØT(46)=0.0001
      PØT(50)=SZF/SF15
      PØT(52)=A10/SF11
      PØT(53)=.9999
      IF(TEST(7).GT.0) GØ TØ 23
      WRITE(6,9000)
      DØ 777 I=1,15,2
      IPLS=I+1
      WRITE(6,8001)KPØT(I),PØT(KPØT(I)),KPØT(IPLS),PØT(KPØT(IPLS))
  777 CØNTINUE
      DØ 778 I=17,41,2
      IPLS=I+1
      WRITE(6,8002)KPØT(I),PØT(KPØT(I)),KPØT(IPLS),PØT(KPØT(IPLS))
  778 CØNTINUE
      WRITE(6,107)
      WRITE(6,780)
      WRITE(6,122)
      WRITE(6,120)SF27,SF4,SF28,SF5,SF29,SF6,SF7,SF13,SF14,SF15,SF16,
     XSF11,SF17,SF9,SF12,SF20,SF10,SF1,SF18,SF8
      WRITE(6,123)
      WRITE(6,121)SF7,SF5,SF6,SF6,SF6,SF6,SF27,SF1,SF2,SF3,SF28,SF29
      WRITE(6,107)
   23 CØNTINUE
      CALL PØTSET
      CALL SETPØT (4HP000,PØT(0),4HP001,PØT(1),4HP002,PØT(2),
     14HP003,PØT(3),4HP004,PØT(4),4HP005,PØT(5),4HP006,PØT(6),
     24HP007,PØT(7),4HP010,PØT(10),4HP011,PØT(11),4HP012,PØT(12),
     34HP013,PØT(13),4HP014,PØT(14),4HP015,PØT(15),4HP016,PØT(16),
     44HP017,PØT(17),4HP020,PØT(20),4HP021,PØT(21),4HP022,PØT(22),
```

```
54HP023,PØT(23),4HP024,PØT(24),4HP025,PØT(25),4HP026,PØT(26),
64HP027,PØT(27),4HP030,PØT(30),4HP031,PØT(31),4HP032,PØT(32),
74HP033,PØT(33),4HP034,PØT(34),4HP035,PØT(35),4HP036,PØT(36),
84HP037,PØT(37),4HP040,PØT(40),4HP041,PØT(41),4HP042,PØT(42),
94HP043,PØT(43),4HP044,PØT(44),4HP045,PØT(45),4HP046,PØT(46),
X4HP050,PØT(50),4HP052,PØT(52),4HP053,PØT(53))
 RETURN
 END
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                    COMPUTATION SUBROUTINE                           *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*     DIMENSION - EQUIVALENCE - DATA - COMMON STATEMENTS              *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      SUBROUTINE LOOPER
      DIMENSION ISQ(30),XSTART(15),XEND(15),YSTART(15),YEND(15),ZSTART(1
     X5),ZEND(15),IDL(38),TLINF(112),RT(4,3),HM(3,3),A(5),CA(5),SA(5),C(
     X24),ITEX15(4),SDOT(3),ADOTN(5),AD(20),AA(12),SFA(5),ADOTO(5),ITEX1
     X0(8),ITEX11(6),ITEX12(4),ITEX13(4),ITEX14(6),ITEX20(4),ITEX21(10),
     XITEX22(6),ITEX23(11),ITEX24(11),ITEX25(4),ITEX26(11),ITEX27(4),ITE
     XX28(12),ITEX29(6),ITEX50(3),ITEX51(8),ITEX52(8),ITEX53(7),ITEX54(7
     X),ITEX55(7),ITEX56(6),NULL(2),ITEX30(8),ITEX31(7),ITEX32(11),ITEX3
     X3(7),ITEX34(12),ITEX35(11),ITEX36(3),ITEX37(12),ITEX38(11),ITEX39(
     X11),ITEX40(2),ITEX41(7),ITEX42(5),ITEX44(6)
      COMMON COEFAB(15,19,9),COEFA(16:24,19),TRIG(361),IDIR(3),ITDIR(20)
     X,NUM,SF1,SF2,SF3,SF4,SF5,SF6,SF7,SF14,SF15,SF16,SF17,SF18,SF19,SF2
     X0,SF21,SF22,SF23,SF24,SF25,SF26,SF27,SF28,SF29,SF30,SF31,SF32,SF33
     X,TRIGC(361),B,CB,SF34,SF35,SF36,SF37,SF38,SF39,SF40,IDEV,SZF,SF8,S
     XF9,SF10,SF11,SF12
      EQUIVALENCE (SF8,SFA(1)),(CA(1),CCA1),(CA(2),CCA2),(SA(1),SSA1),(S
     XA(2),SSA2),(CA(3),CCA3),(CA(4),CCA4),(CA(5),CCA5),(SA(3),SSA3),(SA
     X(4),SSA4),(SA(5),SSA5),(AD(7),QS,Q),(AD(1),A(1)),(AD(2),A(2)),(AD(
     X3),A(3)),(AD(4),A(4)),(AD(5),A(5)),(AD(6),P),(AD(8),R),(AD(9),TM),
     X(AD(10),DIT),(AD(11),DA),(AD(12),DR),(AD(13),V),(AD(14),QUE),(AD(1
     X5),SXN),(AD(16),SYN),(AD(17),SZN),(AA(1),VDOT),(AA(2),ADOTN(1)),(A
     XA(3),ADOTN(2)),(AA(4),ADOTN(3)),(AA(5),ADOTN(4)),(AA(6),ADOTN(5)),
     X(AA(7),ALI),(AA(8),SDOT(1)),(AA(9),SDOT(2)),(AA(10),SDOT(3)),(AA(1
     X1),AMI),(AA(12),ANI),(AD(18),PDOTN),(AD(19),QDOTN),(AD(20),RDOTN)
      DATA AD/12*0.0,.62,.38,6*0.0/,NDA/12/,NAD/20/,G/32.2/,ADOTO/5*0.0/
     X,VDOTO/0.0/,SFACTOR/.5/
```

```
    1 FØRMAT(I1)
    2 FØRMAT(8F8.0)
   10 FØRMAT('INSTRUCTIØNS     ')
   11 FØRMAT('PLACE CØNTRØLS IN NEUTRAL PØSITIØN WITH ')
   12 FØRMAT('THRØTTLE AT WHITE MARK. ')
   13 FØRMAT('WHEN INSTRUCTIØNS ARE UNDERSTØØD, PUNCH THE ')
   14 FØRMAT('BUTTØN ØN THE THRØTTLE PLATE FØR THE GRAPHIC')
   15 FØRMAT('PRESENTATIØN.    ')
   16 FØRMAT('WHEN READY TØ FLY PUNCH THE BUTTØN ØN THE    ')
   17 FØRMAT('CØNTRØL STICK.   ')
   18 FØRMAT('TØ ABØRT A RUN WHILE FLYING, PUNCH THE BUTTØN    ')
   19 FØRMAT('ØN THE THRØTTLE PLATE.   ')
   20 FØRMAT(' ',////)
   21 FØRMAT(' ',47X,'EARTH GRID REFERENCE LINES')
   22 FØRMAT('0',48X,'START',43X,'END',//,19X,'LINE',14X,'X',12X,'Y',14X
     X,'Z',21X,'X',12X,'Y',14X,'Z',///)
   23 FØRMAT(' ',19X,I2,12X,3(F8.0,5X),9X,3(F8.0,5X),//)
   24 FØRMAT('1',' ')
  139 FØRMAT('TØ FLY AGAIN PUNCH THE BUTTØN    ')
  140 FØRMAT('ØN THE CØNTRØL STICK.    ')
  141 FØRMAT('TØ RECEIVE THE  ')
  142 FØRMAT('PRØGRAM ØPTIØNS,')
  143 FØRMAT('PUNCH THE BUTTØN ØN THE ')
  144 FØRMAT('THRØTTLE PLATE  ')
  150 FØRMAT('THE FØLLØWING PRØGRAM ØPTIØNS    ')
  151 FØRMAT('ARE ØFFERED AT THIS TIME :  ')
  152 FØRMAT('1. TØ STØP PRØGRAM - TYPE A 1 FØLLØWED BY A ')
  153 FØRMAT('DECIMAL PØINT AND A RETURN. ')
  154 FØRMAT('2. TØ FLY AGAIN WITH SAME PRØGRAM PARAMETERS -  ')
  155 FØRMAT('TYPE A 2 FØLLØWED BY A DECIMAL PØINT AND     ')
  156 FØRMAT('A RETURN.    ')
  157 FØRMAT('3. TØ CHANGE ANY PRØGRAM PARAMETER - LØAD AND    ')
  158 FØRMAT('READY CARD READER WITH CØMPLETE DATA DECK - ')
  159 FØRMAT('TYPE A 3 FØLLØWED BY A DECIMAL PØINT AND A  ')
  160 FØRMAT('RETURN. ')
```

```
161 FORMAT('TYPE YOUR SELECTION HERE     ')
162 FORMAT('USE A DECIMAL POINT ')
164 FORMAT('INPUT ERROR TRY AGAIN    ')
250 FORMAT('SPIN RESULTS')
251 FORMAT('ANGLE OF ATTACK = ',F6.2,' DEGREES')
252 FORMAT('PITCH ANGLE = ',F7.2,' DEGREES    ')
253 FORMAT('ROLL ANGLE = ',F7.2,' DEGREES')
254 FORMAT('YAW RATE = ',F7.2,' DEG/SEC  ')
255 FORMAT('VELOCITY = ',F8.2,' FT/SEC  ')
256 FORMAT('ALTITUDE = ',F7.0,' FT    ')
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*    SET CONSTANTS OF PROGRAM                                         *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
    F=1.5
    SN=-SFACTOR
    SF=SFACTOR*F
    XTS=XTE=YTS=-1000000.
    YTE=1000000.
    ZTS=ZTE=0.0
    TAU=.08*1.5
    HM(2,1)=0.0
    GEE=G/SF7
    B2=B/2.0
    CB2=CB/2.0
    IDE(1)=IHEAD(0,10)
    K=0
    DO 209 I=1,14
    READ(5,2)(TLINE(J+K),J=1,8)
    K=K+8
209 CONTINUE
    IF(TEST(7).GT.0) GO TO 25
    WRITE(6,20)
    WRITE(6,21)
```

```
      WRITE(6,22)
      K=1
      DO 100 I=1,14
      WRITE(6,23)I,TLINE(K),TLINE(K+1),TLINE(K+2),TLINE(K+4),TLINE(K+5),
     XTLINE(K+6)
      K=K+8
  100 CONTINUE
      WRITE(6,24)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                    BUILD FIXED PORTION OF GRAPHICS                  *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
   25 ISQ(1)=IHEAD(0,10)
      ISQ(2)=IPACK(1.0,1.0,0)
      ISQ(3)=IPACK(1.0,-1.0,1)
      ISQ(4)=IPACK(-1.0,-1.0,1)
      ISQ(5)=IPACK(-1.0,1.0,1)
      ISQ(6)=IPACK(1.0,1.0,1)
      ISQ(7)=IPACK(-.2,-1.0,0)
      ISQ(8)=IPACK(-.2,-1.35,1)
      ISQ(9)=IPACK(.2,-1.35,1)
      ISQ(10)=IPACK(.2,-1.0,1)
      ISQ(11)=IPACK(-.2,-1.25,0)
      ISQ(12)=IPACK(.2,-1.25,1)
      ISQ(13)=IPACK(0.0,-1.02,0)
      ISQ(14)=IPACK(0.0,-1.07,1)
      ISQ(15)=IPACK(.04,-1.25,0)
      ISQ(16)=IPACK(.04,-1.27,1)
      ISQ(17)=IPACK(.04,-1.29,0)
      ISQ(18)=IPACK(.04,-1.31,1)
      ISQ(19)=IPACK(.04,-1.33,0)
      ISQ(20)=IPACK(.04,-1.35,1)
      ISQ(21)=IPACK(-.04,-1.25,0)
      ISQ(22)=IPACK(-.04,-1.27,1)
```

```
      ISQ(23)=IPACK(-.04,-1.29,0)
      ISQ(24)=IPACK(-.04,-1.31,1)
      ISQ(25)=IPACK(-.04,-1.33,0)
      ISQ(26)=IPACK(-.04,-1.35,1)
      ISQ(27)=IPACK(.092,-1.07,0)
      ISQ(28)=IPACK(.115,-1.03,1)
      ISQ(29)=IPACK(-.092,-1.07,0)
      ISQ(30)=IPACK(-.115,-1.03,1)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                         THE INSTRUCTIONS                            *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 1001 CALL SETLINES(5,-1.0,6,+1.0,7,-1.0,8,-1.0)
      CALL DTINIT(IDEV,ITDIR,20,IER)
      ENCODE(16,10,ITEX20)
      ENCODE(40,11,ITEX21)
      ENCODE(24,12,ITEX22)
      ENCODE(44,13,ITEX23)
      ENCODE(44,14,ITEX24)
      ENCODE(16,15,ITEX25)
      ENCODE(44,16,ITEX26)
      ENCODE(16,17,ITEX27)
      ENCODE(48,18,ITEX28)
      ENCODE(24,19,ITEX29)
      CALL TEXT8(IDEV,ITEX20,4,1,30,3,3,IER)
      CALL TEXT8(IDEV,ITEX21,10,5,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX22,6,7,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX23,11,11,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX24,11,13,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX25,4,15,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX26,11,19,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX27,4,21,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX28,12,25,1,2,3,IER)
      CALL TEXT8(IDEV,ITEX29,6,27,1,2,3,IER)
```

```
      CALL RESET (1000)
  900 IF (TEST(2).GT.0) GO TO 900
      CALL SETLINES(5,+1.0,6,-1.0)
  805 IF (TEST(2).LT.0) GO TO 805
      CALL DGINIT(IDEV,IDIR,3,IER)
      CALL DTINIT(IDEV,ITDIR,20,IER)
      CALL GRAPHO(IDEV,ISQ,30,1,IER)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                              THE LOOP                               *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 1000 CALL WRITECLOCK(0)
      CALL STARTCLOCK
      IF(TEST(3).GT.0) GO TO 950
      CALL COMPUTE
      CALL SETLINES(6,+1.0)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                              A/D - D/A                              *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  950 CALL ADDA(AD,NAD,AA,NDA)
      DO 960 I=1,20
      IF(ABS(AD(I)).GT..95) GO TO 6000
  960 CONTINUE
      IF(ABS(A(3)).GE..9) CALL SETLINES(7,+1.0)
      IF(ABS(A(5)).GE..9) CALL SETLINES(8,+1.0)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                        PREDICTOR AND UPDATE                         *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      A(1)=A(1)+TAU*ADOTO(1)*SF35
      A(2)=A(2)+TAU*ADOTO(2)*SF36
```

```
      A(3)=A(3)+TAU*ADØTØ(3)*SF37
      A(4)=A(4)+TAU*ADØTØ(4)*SF38
      A(5)=A(5)+TAU*ADØTØ(5)*SF39
      V=V+TAU*VDØTØ*SF40
      P=P-TAU*PDØTN*SF4
      Q=Q-TAU*QDØTN*SF5
      R=R-TAU*RDØTN*SF6
      DØ 3400 I=1,5
      ADØTØ(I)=-ADØTN(I)
 3400 CØNTINUE
      VDØTØ=VDØT
* * * * * * * * * * * * * * * * * ** * * * * * * * * * * * * * * * * *
*                                                                     *
*                        SINE AND CØSINE LØØKUP                       *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      DØ 3100 I=1,5
      ARG=A(I)*SFA(I)
      IF(ARG.GT.180.) ARG=ARG-360.
      IF(ARG.LT.-180.) ARG=ARG+360.
      ARG=ARG+181.
      IARG=ARG
      SA(I)=TRIG(IARG)+(ARG-IARG)*(TRIG(IARG+1)-TRIG(IARG))
      CA(I)=TRIGC(IARG)+(ARG-IARG)*(TRIGC(IARG+1)-TRIGC(IARG))
 3100 CØNTINUE
      PS=P*CA(1)+R*SA(1)*SF21
      RS=-P*SA(1)/SF21+R*CA(1)
      PB=P*B2/V
      QB=Q*CB2/V
      RB=R*B2/V
* * * * * * * * * * * * * * * * * ** * * * * * * * * * * * * * * * * *
*                                                                     *
*                         CØEFFICIENT LØØKUP                          *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
      ALPHA=A(1)*SF8/5.0+1.0
      IALPHA=ALPHA
      BETA=A(2)*SF9/10.0+5.0
      IBETA=BETA
      IF(IALPHA.GT.18) IALPHA=18
      IF(IALPHA.LT.1) IALPHA=1
      IF(IBETA.GT.8) IBETA=8
      IF(IBETA.LT.1) IBETA=1
      DO 3200 I=1,15
      COF1=COEFAB(I,IALPHA,IBETA)+(ALPHA-IALPHA)*(COEFAB(I,IALPHA+1,IBET
     XA)-COEFAB(I,IALPHA,IBETA))
      COF2=COEFAB(I,IALPHA,IBETA+1)+(ALPHA-IALPHA)*(COEFAB(I,IALPHA+1,IB
     XETA+1)-COEFAB(I,IALPHA,IBETA+1))
      C(I)=COF1+(BETA-IBETA)*(COF2-COF1)
 3200 CONTINUE
      DO 3300 I=16,24
      C(I)=COEFA(I,IALPHA)+(ALPHA-IALPHA)*(COEFA(I,IALPHA+1)-COEFA(I,IAL
     XPHA))
 3300 CONTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*   SET UP ROTATION AND TRANSLATION MATRICES                          *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      RT(1,1)=CCA3*CCA4
      RT(1,2)=SSA3*CCA5-CCA3*SSA4*SSA5
      RT(1,3)=SSA3*SSA5+CCA3*SSA4*CCA5
      RT(2,1)=-CCA4*SSA3
      RT(2,2)=CCA3*CCA5+SSA3*SSA4*SSA5
      RT(2,3)=CCA3*SSA5-SSA3*SSA4*CCA5
      RT(3,1)=-SSA4
      RT(3,2)=-CCA4*SSA5
      RT(3,3)=CCA4*CCA5
      DO 211 J=1,3
      RT(4,J)=RT(1,J)*SX+RT(2,J)*SY+RT(3,J)*SZ
```

```
  211 CONTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*         RESOLUTION OF AERODYNAMIC FORCES AND MOMENTS                 *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      FXAM=QUE*(C(5)+DIT*C(15)+QB*C(24))
      FYAM=QUE*(C(4)+RB*C(19)+PB*C(16)+DR*C(9)+DA*C(12))
      FZAM=QUE*(C(6)+QB*C(22)+DIT*C(7))
      FXSM=(TM-GEE*SA(4)+FXAM)*CA(1)+(GEE*CA(4)*CA(5)+FZAM)*SA(1)
      FYSM=GEE*CA(4)*SA(5)+FYAM
      FZWM=-(TM-GEE*SA(4)+FXAM)*SA(1)+(GEE*CA(4)*CA(5)+FZAM)*CA(1)
      VDOT=FXSM*CA(2)+FYSM*SA(2)
      FYWM=-FXSM*SA(2)+FYSM*CA(2)
      ADOTN(1)=-FZWM*SF31/(V*CA(2))+PS*SA(2)*SF25/CA(2)-QS
      ADOTN(2)=-FYWM*SF32/V+RS
      ADOTN(3)=-(R*CA(5)+Q*SA(5)*SF26)/CA(4)
      ADOTN(4)=-Q*CA(5)*SF26+R*SA(5)
      ADOTN(5)=-P/SF21+ADOTN(3)*SA(4)
      IF(ADOTN(3).GT..99) ADOTN(3)=.99
      IF(ADOTN(3).LT.-.99) ADOTN(3)=-.99
      ALI=(C(1)+PB*C(17)+RB*C(20)+DA*C(13)+DR*C(10))*QUE
      AMI=(C(2)+QB*C(23)+DIT*C(8))*QUE
      ANI=(C(3)+PB*C(18)+RB*C(21)+DA*C(14)+DR*C(11))*QUE
      VX=V*CA(2)*CA(1)
      VY=V*SA(2)
      VZ=V*CA(2)*SA(1)
      SDOT(1)=VX*RT(1,1)+VY*RT(1,2)+VZ*RT(1,3)
      SDOT(2)=VX*RT(2,1)+VY*RT(2,2)+VZ*RT(2,3)
      SDOT(3)=VX*RT(3,1)+VY*RT(3,2)+VZ*RT(3,3)
      SX=-SXN*SF13
      SY=SYN*SF14
      SZ=-SZN*SF15
      CALL SETLINES(7,-1.0,8,-1.0)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
*                                                                     *
*    FØRM ARRAY ØF LINES                                              *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      J=1
      DØ 206 I=1,112,8
-03150326
      XSTART(J)=TLINE(I)*RT(1,1)+TLINE(I+1)*RT(2,1)+TLINE(I+2)*RT(3,1)+R
     XT(4,1)
      YSTART(J)=TLINE(I)*RT(1,2)+TLINE(I+1)*RT(2,2)+TLINE(I+2)*RT(3,2)+R
     XT(4,2)
      ZSTART(J)=TLINE(I)*RT(1,3)+TLINE(I+1)*RT(2,3)+TLINE(I+2)*RT(3,3)+R
     XT(4,3)
      XEND(J)=TLINE(I+4)*RT(1,1)+TLINE(I+5)*RT(2,1)+TLINE(I+6)*RT(3,1)+R
     XT(4,1)
      YEND(J)=TLINE(I+4)*RT(1,2)+TLINE(I+5)*RT(2,2)+TLINE(I+6)*RT(3,2)+R
     XT(4,2)
      ZEND(J)=TLINE(I+4)*RT(1,3)+TLINE(I+5)*RT(2,3)+TLINE(I+6)*RT(3,3)+R
     XT(4,3)
      J=J+1
  206 CØNTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*   BUILD THE HØRIZØN                                                 *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      HM(1,1)=CCA4
      HM(1,2)=-SSA4*SSA5
      HM(1,3)=SSA4*CCA5
      HM(2,2)=CCA5
      HM(2,3)=SSA5
      HM(3,1)=-SSA4
      HM(3,2)=-CCA4*SSA5
      HM(3,3)=CCA4*CCA5
      XSTART(15)=XTS*HM(1,1)
```

```
      XEND(15)=XTE*HM(1,1)
      YSTART(15)=XTS*HM(1,2)+YTS*HM(2,2)
      YEND(15)=XTE*HM(1,2)+YTE*HM(2,2)
      ZSTART(15)=XTS*HM(1,3)+YTS*HM(2,3)
      ZEND(15)=XTE*HM(1,3)+YTE*HM(2,3)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*     VIEWING PLANE CHØP                                              *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  403 DØ 202 I=1,15
      IF(XSTART(I).LE.0.0) GØ TØ 202
      IF(XEND(I).GT.0.0) GØ TØ 203
      SK=XSTART(I)/(XSTART(I)-XEND(I))
      YSTART(I)=YSTART(I)+(YEND(I)-YSTART(I))*SK
      ZSTART(I)=ZSTART(I)+(ZEND(I)-ZSTART(I))*SK
      XSTART(I)=0.0
      GØ TØ 202
  203 XSTART(I)=XEND(I)=0.0
      YSTART(I)=YEND(I)=ZSTART(I)=ZEND(I)=2.0
  202 CØNTINUE
      DØ 204 I=1,15
      IF(XEND(I).LE.0.0) GØ TØ 204
      SK=XEND(I)/(XEND(I)-XSTART(I))
      YEND(I)=YEND(I)+(YSTART(I)-YEND(I))*SK
      ZEND(I)=ZEND(I)+(ZSTART(I)-ZEND(I))*SK
      XEND(I)=0.0
  204 CØNTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*     BUILD PERSPECTIVE                                               *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      DØ 205 I=1,15
      DIV=XSTART(I)*SN+SF
```

```
      XSTART(I)=YSTART(I)*F/DIV
      YSTART(I)=ZSTART(I)*F/DIV
      DIV=XEND(I)*SN+SF
      XEND(I)=YEND(I)*F/DIV
      YEND(I)=ZEND(I)*F/DIV
  205 CØNTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*   WINDØW CHØP                                                       *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      DØ 300 I=1,15
      IX1=XSTART(I)
      IX2=XEND(I)
      IY1=YSTART(I)
      IY2=YEND(I)
      IF(IX1.GE.1.AND.IX2.GE.1) GØ TØ 310
      IF(IX1.LE.-1.AND.IX2.LE.-1) GØ TØ 310
      IF(IY1.GE.1.AND.IY2.GE.1) GØ TØ 310
      IF(IY1.LE.-1.AND.IY2.LE.-1) GØ TØ 310
      IAGN=1
      X=XSTART(I)
      Y=YSTART(I)
      IX=IX1
      IY=IY1
      SLØPE=(YSTART(I)-YEND(I))/(XSTART(I)-XEND(I))
  301 IF(IX)311,312,313
  311 VINSCT=Y+SLØPE*(-1.-X)
  321 IF(ABS(VINSCT).LE.1.) GØ TØ 326
  323 IF(IY)324,310,325
  326 XTEMP=-1.
      GØ TØ 347
  324 HINSCT=X+(-1.-Y)/SLØPE
      YTEMP=-1.
  322 IF(ABS(HINSCT).GT.1.) GØ TØ 310
```

```
      XTEMP=HINSCT
      GO TO 350
  325 HINSCT=X+(1.-Y)/SLOPE
      YTEMP=1.
      GO TO 322
  312 IF(IY)324,332,325
  332 XTEMP=X
      YTEMP=Y
      GO TO 350
  313 VINSCT=Y+SLOPE*(1.-X)
      IF(ABS(VINSCT).LE.1.) GO TO 346
      GO TO 323
  346 XTEMP=1.
  347 YTEMP=VINSCT
  350 GO TO (351,360),IAGN
  351 X=XEND(I)
      Y=YEND(I)
      IX=IX2
      IY=IY2
      IAGN=2
      XSTART(I)=XTEMP
      YSTART(I)=YTEMP
      GO TO 301
  360 CONTINUE
      XEND(I)=XTEMP
      YEND(I)=YTEMP
      GO TO 300
  310 XEND(I)=-1.
      XSTART(I)=-1.
      YEND(I)=-1.
      YSTART(I)=-1.
  300 CONTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                      *
*       BUILD NEEDLE BALL DISPLAY                                      *
```

```
*                                                                      *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      TX=-.21*SSA5
      TY=.21*CCA5-1.23
      IF((A(5).GE..225).AND.(A(5).LT..675)) TX=-.21;TY=-1.23
      IF((A(5).LE.-.225).AND.(A(5).GT.-.675)) TX=.21;TY=-1.23
      IDE(32)=IPACK(0.0,-1.23,0)
      IDE(33)=IPACK(TX,TY,1)
      BX=1.628*SSA2+.03
      IF((A(2)*SFA(2)).GE.6.0) BX=.17
      IF((A(2)*SFA(2)).LE.-6.0) BX=-.14
      IDE(34)=IPACK(BX,-1.27,0)
      IDE(35)=IPACK(BX,-1.33,1)
      IDE(36)=IPACK((BX-.06),-1.33,1)
      IDE(37)=IPACK((BX-.06),-1.27,1)
      IDE(38)=IPACK(BX,-1.27,1)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                      *
*  BUILD VARIABLE PORTION OF GRAPHICS                                  *
*                                                                      *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      J=2
      DO 207 I=1,15
      IDE(J)=IPACK(XSTART(I),YSTART(I),0)
      IDE(J+1)=IPACK(XEND(I),YEND(I),1)
      J=J+2
  207 CONTINUE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                      *
*                    DISPLAY COMPLETED PICTURE                         *
*                                                                      *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      CALL GRAPH9(IDEV,IDE,38,2,IER)
      IF(TEST(2,4).LT.0) GO TO 6000
  500 CALL READCLOCK(LTR)
```

```
      CALL STOPCLOCK
      GO TO 1000
 6000 CALL HOLD
      CALL STOPCLOCK
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                              SPIN RESULTS                           *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      CALL DTINIT(IDEV,ITDIR,20,IER)
      CALL DGINIT(IDEV,IDIR,3,IER)
      ENCODE(12,250,ITEX50)
      CALL TEXTO(IDEV,ITEX50,3,1,30,3,3,IER)
      A(1)=A(1)*SF8
      ENCODE(32,251,ITEX51)A(1)
      CALL TEXTO(IDEV,ITEX51,8,5,1,2,3,IER)
      A(4)=A(4)*SF11
      ENCODE(32,252,ITEX52)A(4)
      CALL TEXTO(IDEV,ITEX52,8,9,1,2,3,IER)
      A(5)=A(5)*SF12
      ENCODE(28,253,ITEX53)A(5)
      CALL TEXTO(IDEV,ITEX53,7,13,1,2,3,IER)
      R=R*SF6*57.29577
      ENCODE(28,254,ITEX54)R
      CALL TEXTO(IDEV,ITEX54,7,17,1,2,3,IER)
      V=V*SF1
      ENCODE(28,255,ITEX55)V
      CALL TEXTO(IDEV,ITEX55,7,21,1,2,3,IER)
      SZ=-SZ
      ENCODE(24,256,ITEX56)SZ
      CALL TEXTO(IDEV,ITEX56,6,25,1,2,3,IER)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*                            PROGRAM OPTIONS                          *
*                                                                     *
```

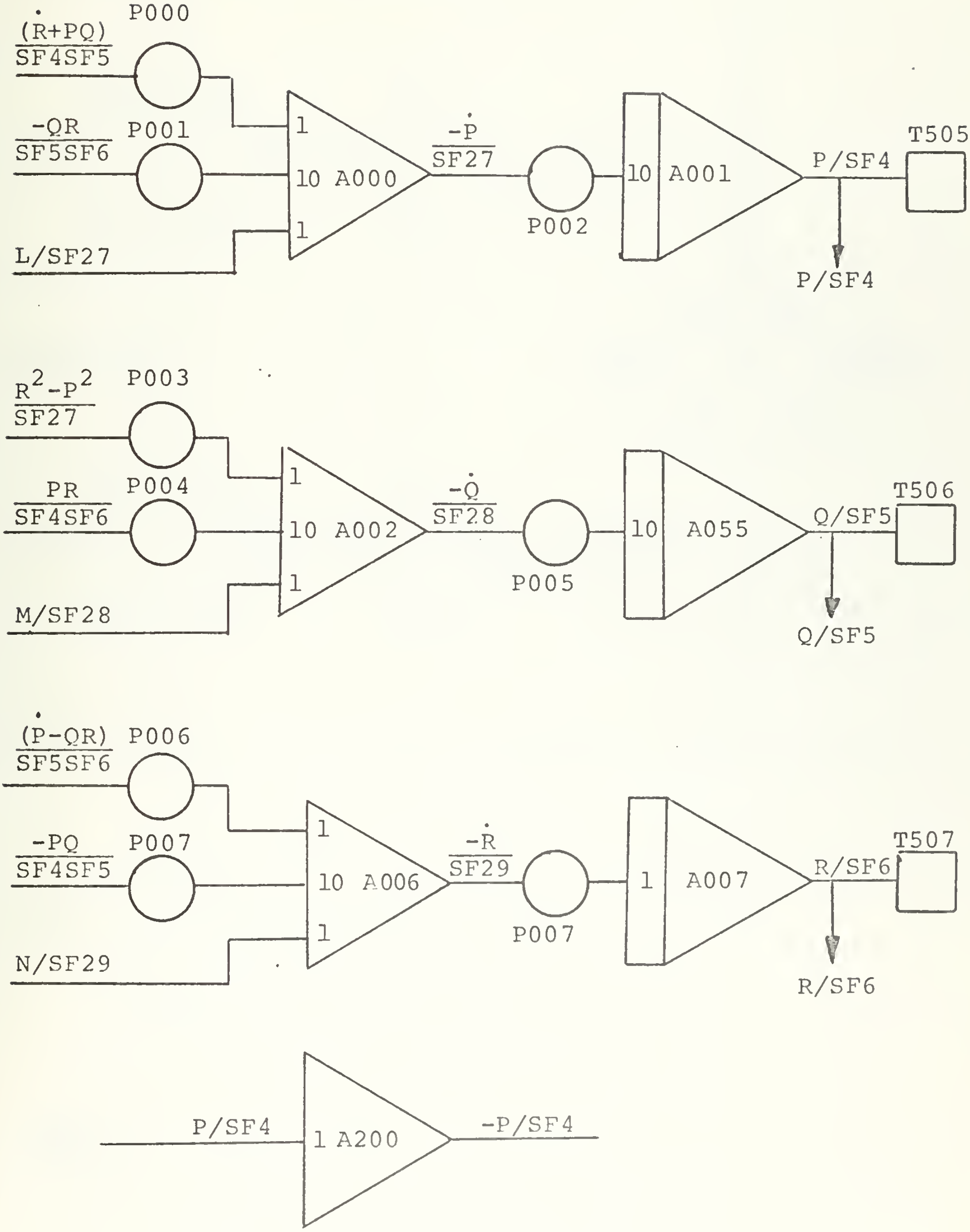
```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
      I=1000000
      CALL DELAY
      CALL DTINIT(IDEV,ITDIR,20,IER)
      CALL DGINIT(IDEV,IDIR,3,IER)
      ENCODE(32,139,ITEX10)
      ENCODE(24,140,ITEX11)
      ENCODE(16,141,ITEX12)
      ENCODE(16,142,ITEX13)
      ENCODE(24,143,ITEX14)
      ENCODE(16,144,ITEX15)
      CALL TEXT0(IDEV,ITEX10,8,7,4,3,3,IER)
      CALL TEXT0(IDEV,ITEX11,6,10,16,3,3,IER)
      CALL TEXT0(IDEV,ITEX12,4,17,10,3,3,IER)
      CALL TEXT0(IDEV,ITEX13,4,20,16,3,3,IER)
      CALL TEXT0(IDEV,ITEX14,6,23,16,3,3,IER)
      CALL TEXT0(IDEV,ITEX15,4,26,28,3,3,IER)
  509 IF(TEST(2).LT.0) GO TO 509
      CALL SETLINES(5,-1.0,6,-1.0)
  510 IF(TEST(3).LT.0) GO TO 1001
      IF(TEST(2).GT.0) GO TO 510
      CALL SETLINES(5,+1.0,6,+1.0)
  512 CALL DGINIT(IDEV,IDIR,3,IER)
      CALL DTINIT(IDEV,ITDIR,20,IER)
      ENCODE(32,150,ITEX30)
      ENCODE(28,151,ITEX31)
      ENCODE(44,152,ITEX32)
      ENCODE(28,153,ITEX33)
      ENCODE(48,154,ITEX34)
      ENCODE(44,155,ITEX35)
      ENCODE(12,156,ITEX36)
      ENCODE(48,157,ITEX37)
      ENCODE(44,158,ITEX38)
      ENCODE(44,159,ITEX39)
      ENCODE(8,160,ITEX40)
```

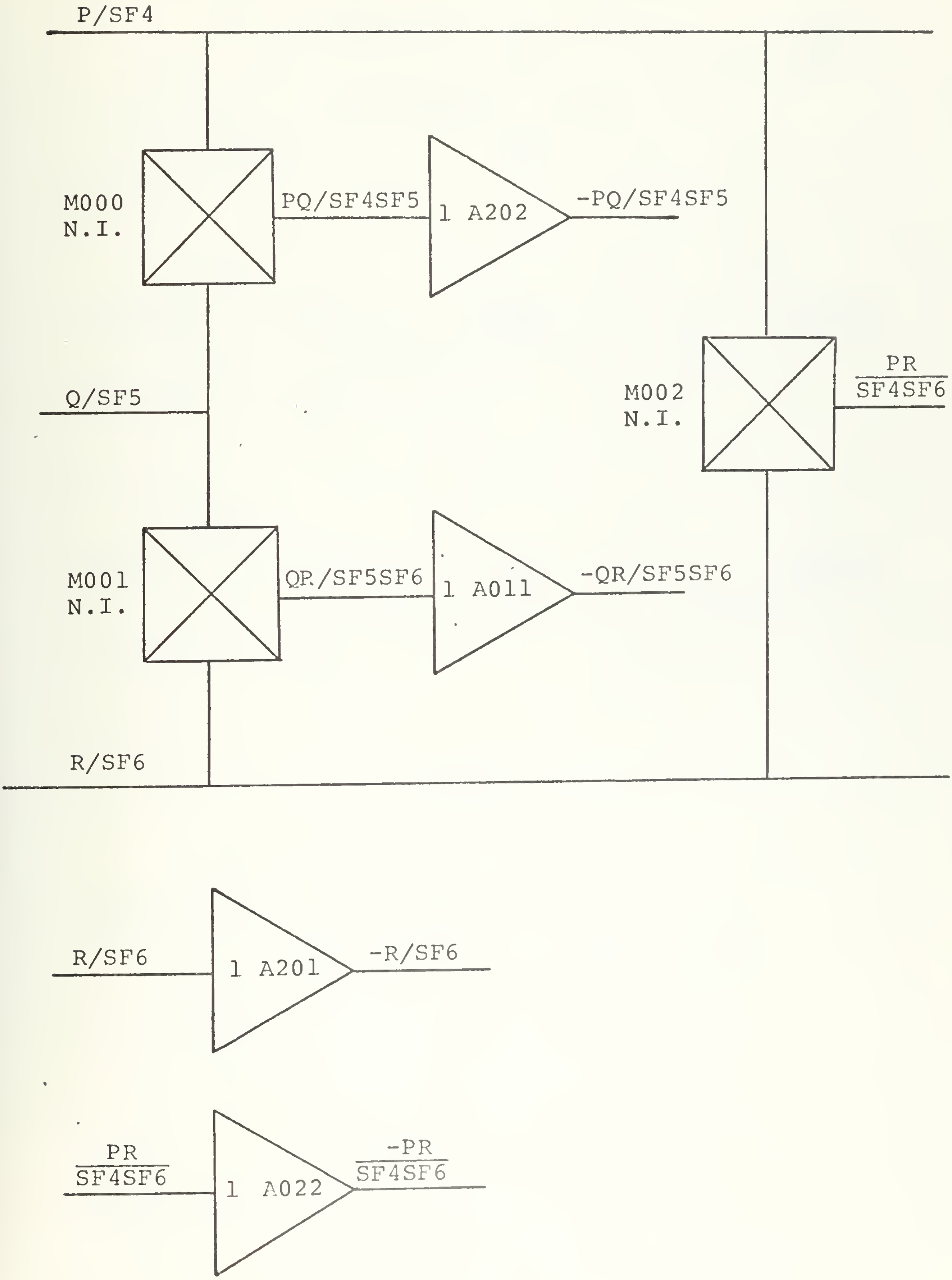
```
      ENCODE(28,161,ITEX41)
      ENCODE(20,162,ITEX42)
      CALL TEXTO(IDEV,ITEX30,8,1,8,2,3,IER)
      CALL TEXTO(IDEV,ITEX31,7,3,8,2,3,IER)
      CALL TEXTO(IDEV,ITEX32,11,7,1,2,3,IER)
      CALL TEXTO(IDEV,ITEX33,7,9,4,2,3,IER)
      CALL TEXTO(IDEV,ITEX34,12,13,1,2,3,IER)
      CALL TEXTO(IDEV,ITEX35,11,15,4,2,3,IER)
      CALL TEXTO(IDEV,ITEX36,3,17,4,2,3,IER)
      CALL TEXTO(IDEV,ITEX37,12,21,1,2,3,IER)
      CALL TEXTO(IDEV,ITEX38,11,23,4,2,3,IER)
      CALL TEXTO(IDEV,ITEX39,11,25,4,2,3,IER)
      CALL TEXTO(IDEV,ITEX40,2,27,4,2,3,IER)
      CALL TEXTO(IDEV,ITEX41,7,31,1,2,3,IER)
      CALL TEXTO(IDEV,ITEX42,5,33,1,2,3,IER)
      NULL(1)=NULL(2)=77777777B
      CALL TEXTR(IDEV,NULL,2,32,60,3,3,IER)
  511 IF(MOD(ITDIR(14),8).EQ.0) GO TO 511
      CALL TEXTI(IDEV,CHOYC,2,0,14,IER)
  631 FORMAT(F8.7)
      DECODE(8,631,CHOYC)CHOYC
      ICHOYC=CHOYC
      IF(ICHOYC.LT.1) ICHOYC=4
      GO TO (8004,1001,8003,513),ICHOYC
  513 CALL DGINIT(IDEV,IDIR,3,IER)
      CALL DTINIT(IDEV,ITDIR,20,IER)
      ENCODE(24,164,ITEX44)
      CALL TEXTO(IDEV,ITEX44,6,20,16,3,3,IER)
      I=300000
      CALL DELAY
      GO TO 512
 8003 NUM=1
 8004 CALL POTSET
      CALL DTINIT(IDEV,ITDIR,20,IER)
      CALL DGINIT(IDEV,IDIR,3,IER)
```

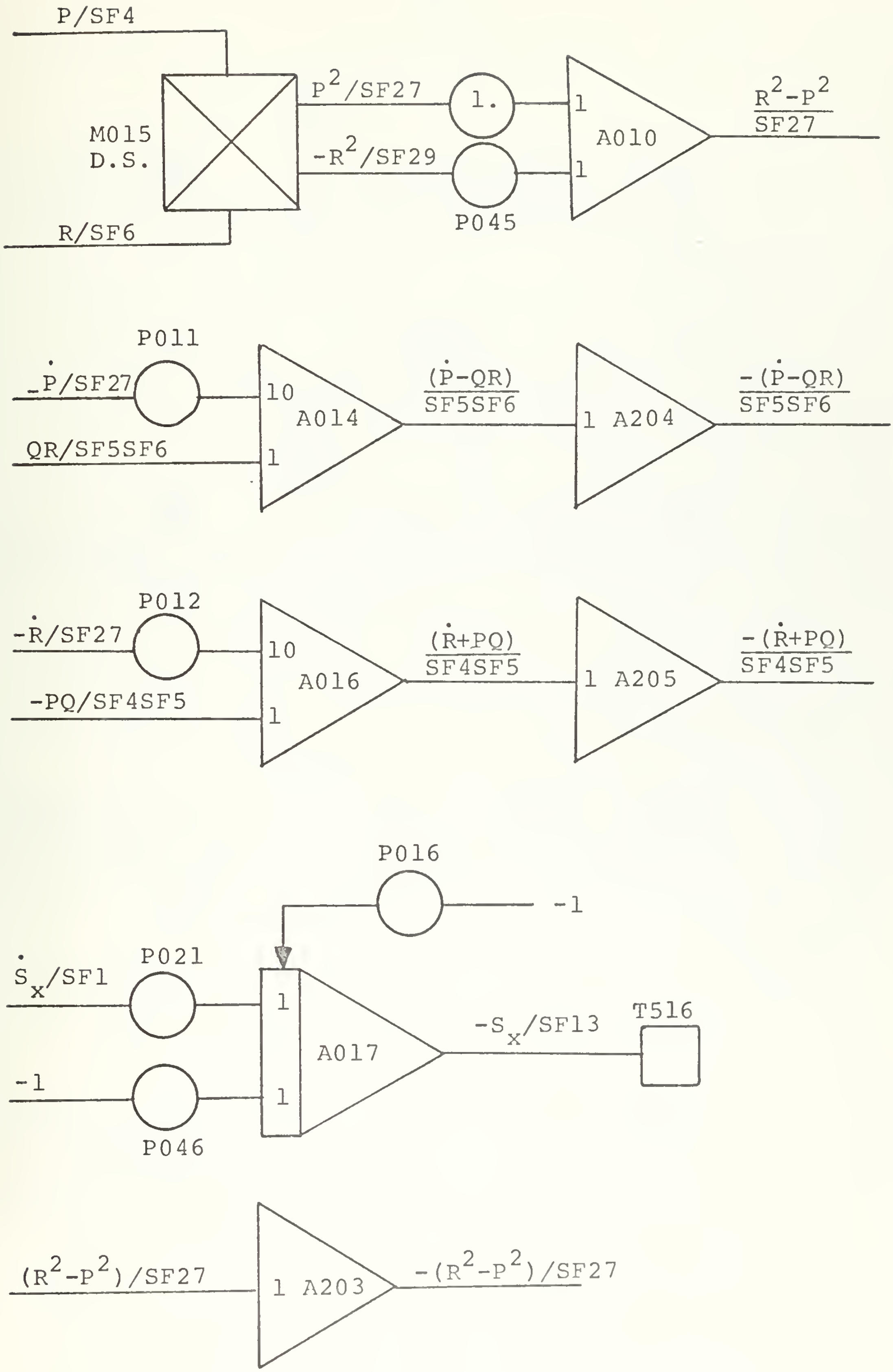
```
      RETURN
      END
```

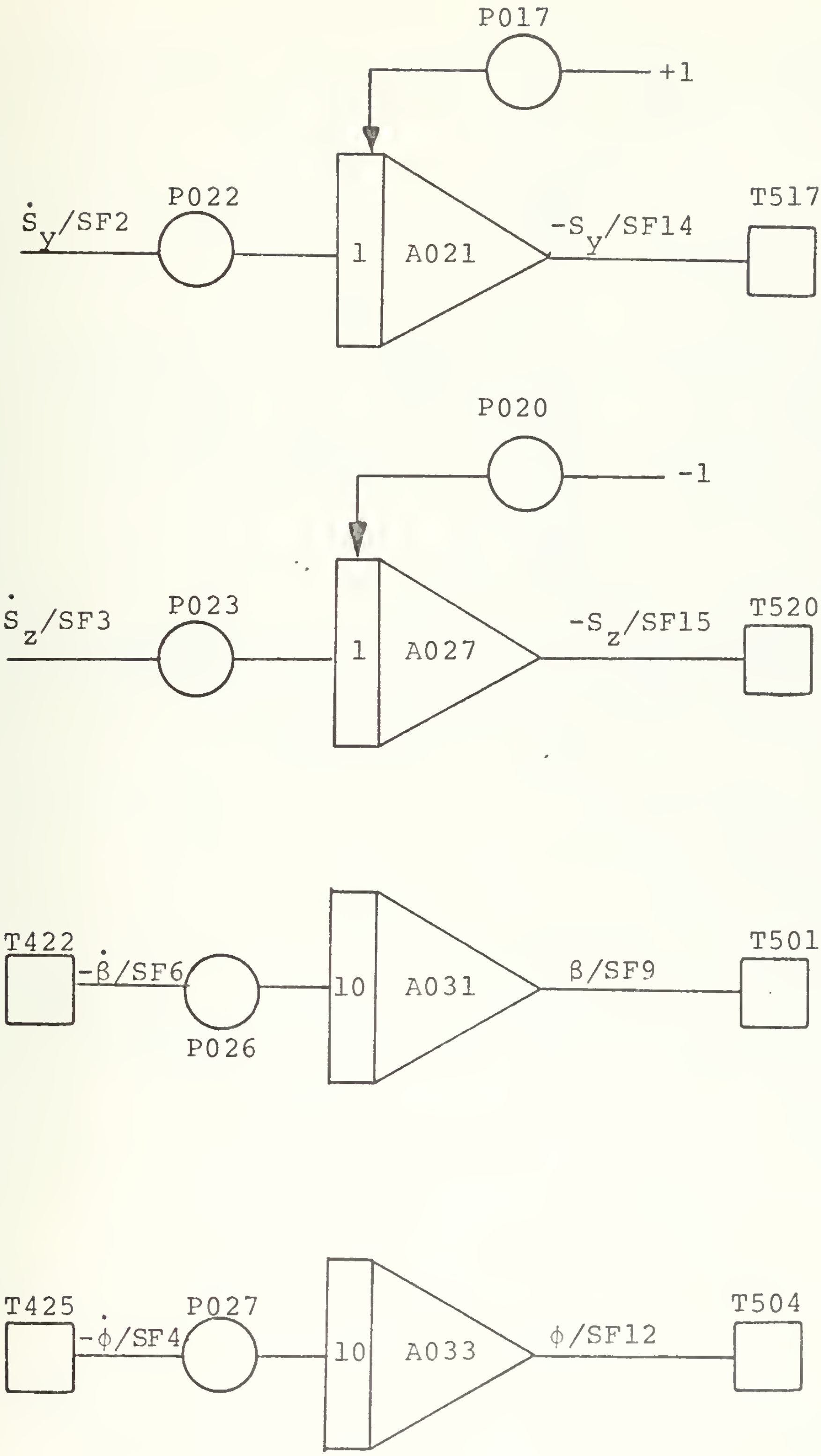
APPENDIX B

THE ANALOG PROGRAM

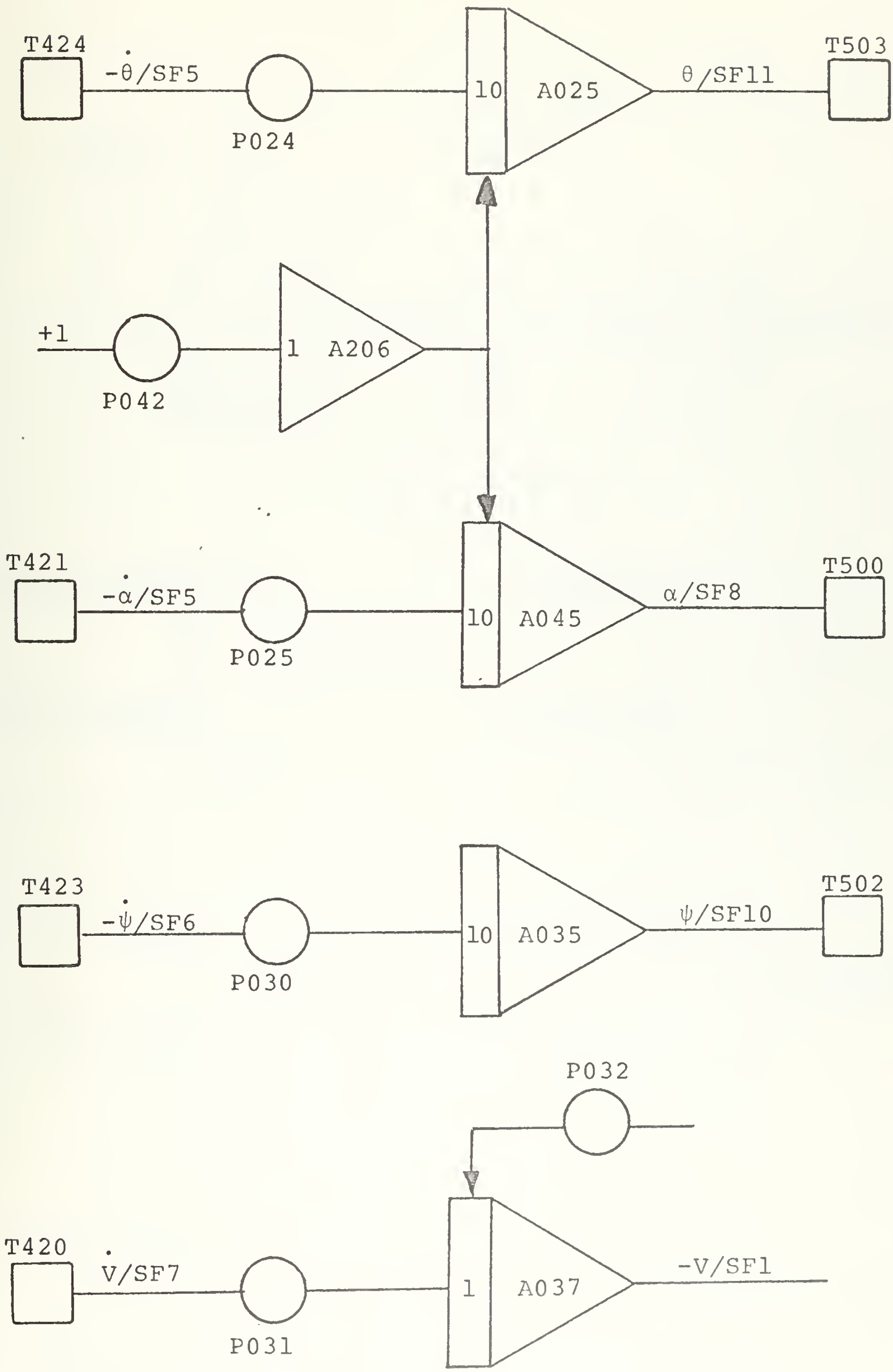


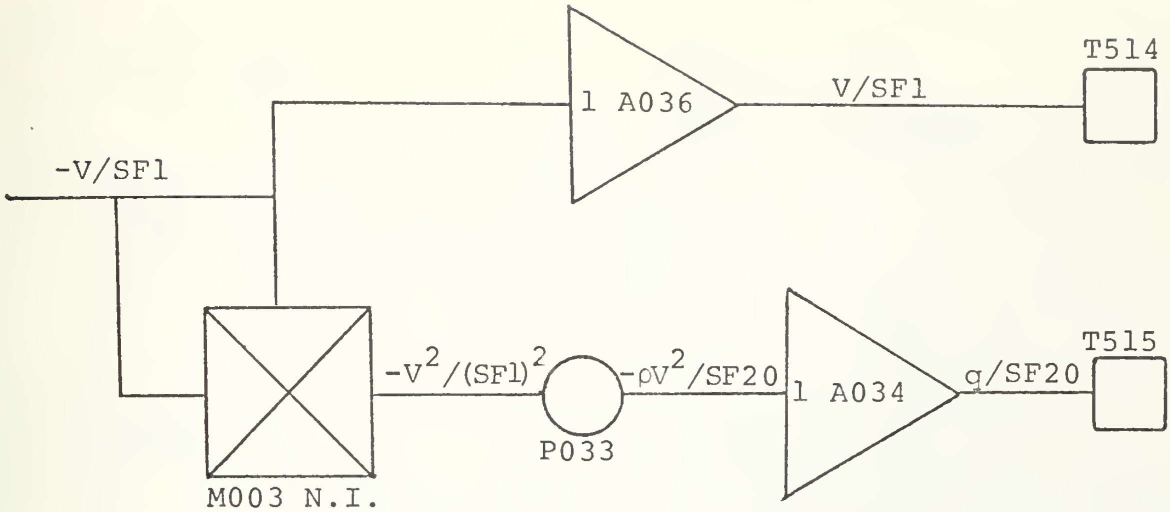

P/SF4
M000
N.I.
PQ/SF4SF5
1 A202
-PQ/SF4SF5
M002
N.I.
PR
SF4SF6
Q/SF5
M001
N.I.
QR/SF5SF6
1 A011
-QR/SF5SF6
R/SF6
R/SF6
1 A201
-R/SF6
PR
SF4SF6
1 A022
-PR
SF4SF6


P/SF4
M015
D.S.
R/SF6
P^2/SF27
-R^2/SF29
1.
P045
1
1
A010
R^2-P^2
SF27
P011
-Ṗ/SF27
QR/SF5SF6
10
1
A014
(Ṗ-QR)
SF5SF6
1 A204
-(Ṗ-QR)
SF5SF6
P012
-Ṙ/SF27
-PQ/SF4SF5
10
1
A016
(Ṙ+PQ)
SF4SF5
1 A205
-(Ṙ+PQ)
SF4SF5
P016
-1
Ṡx/SF1
P021
-1
P046
1
1
A017
-Sx/SF13
T516
(R^2-P^2)/SF27
1 A203
-(R^2-P^2)/SF27

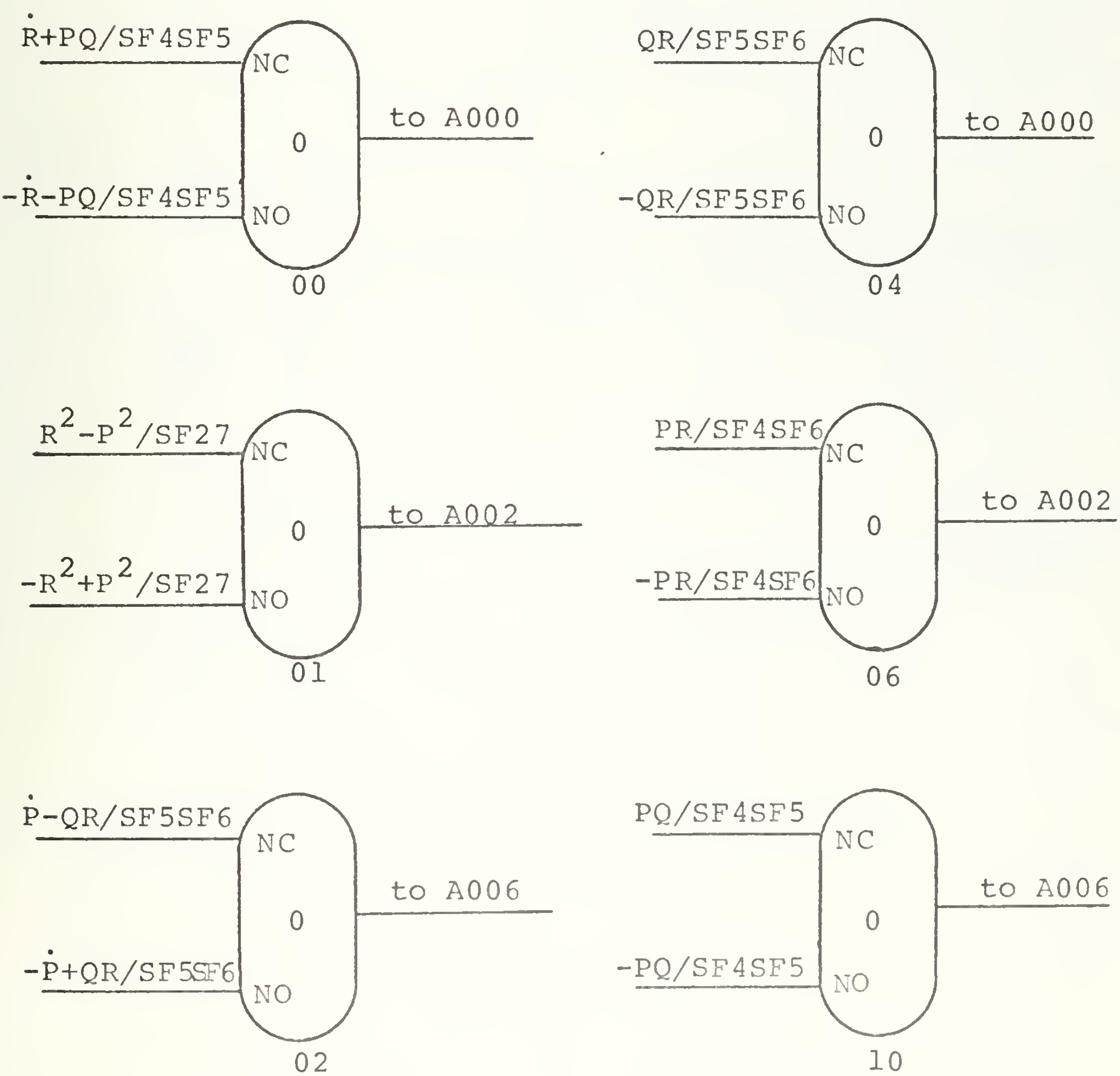


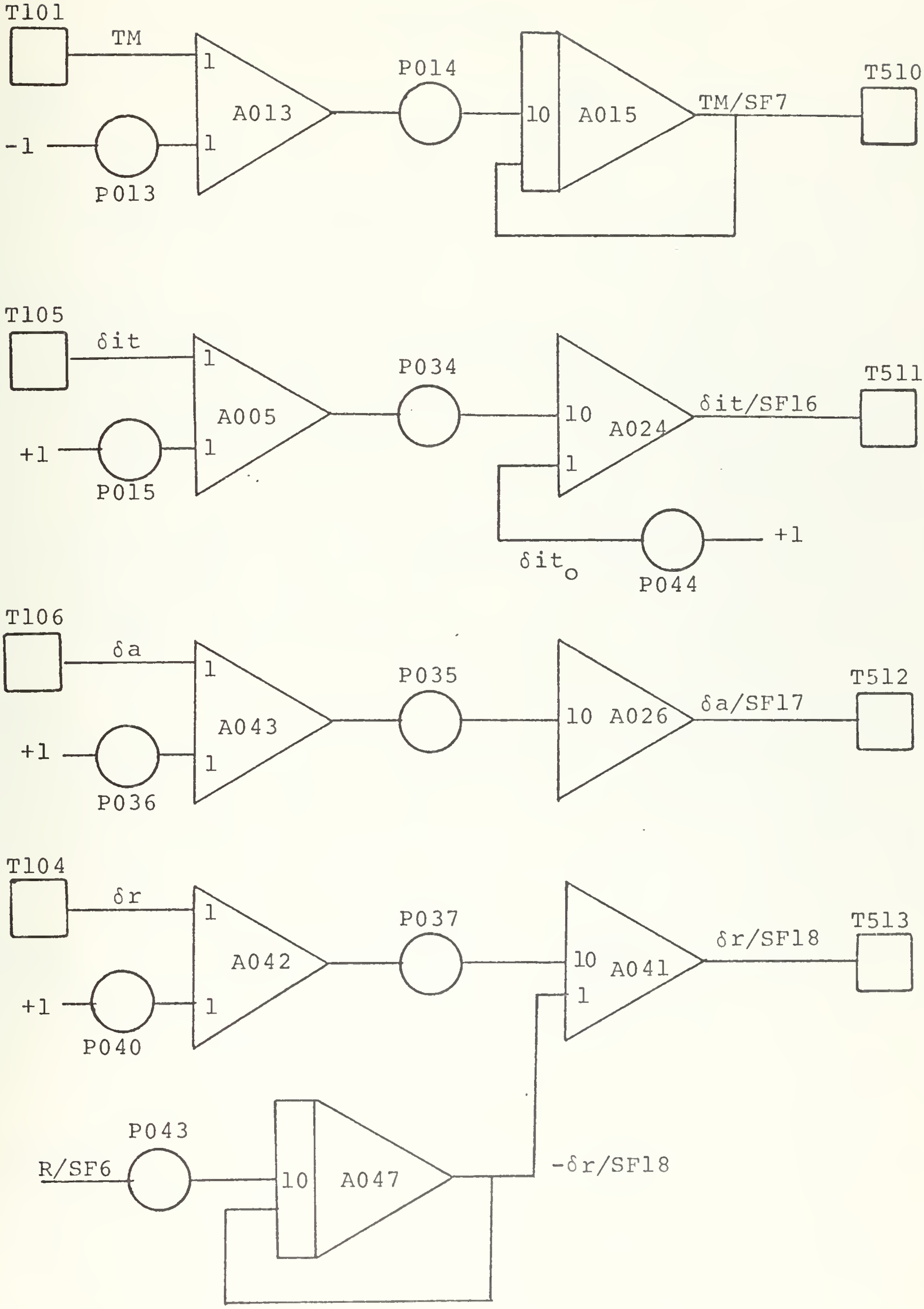
P017
+1
P022
$\dot{S}_y/SF2$
1
A021
$-S_y/SF14$
T517
P020
-1
$\dot{S}_z/SF3$
P023
1
A027
$-S_z/SF15$
T520
T422
$-\dot{\beta}/SF6$
P026
10
A031
$\beta/SF9$
T501
T425
$-\dot{\phi}/SF4$
P027
10
A033
$\phi/SF12$
T504


T424
$-\dot{\theta}$/SF5
P024
10
A025
θ/SF11
T503
+1
P042
1
A206
T421
$-\dot{\alpha}$/SF5
P025
10
A045
α/SF8
T500
T423
$-\dot{\psi}$/SF6
P030
10
A035
ψ/SF10
T502
P032
T420
$\dot{V}$/SF7
P031
1
A037
-V/SF1

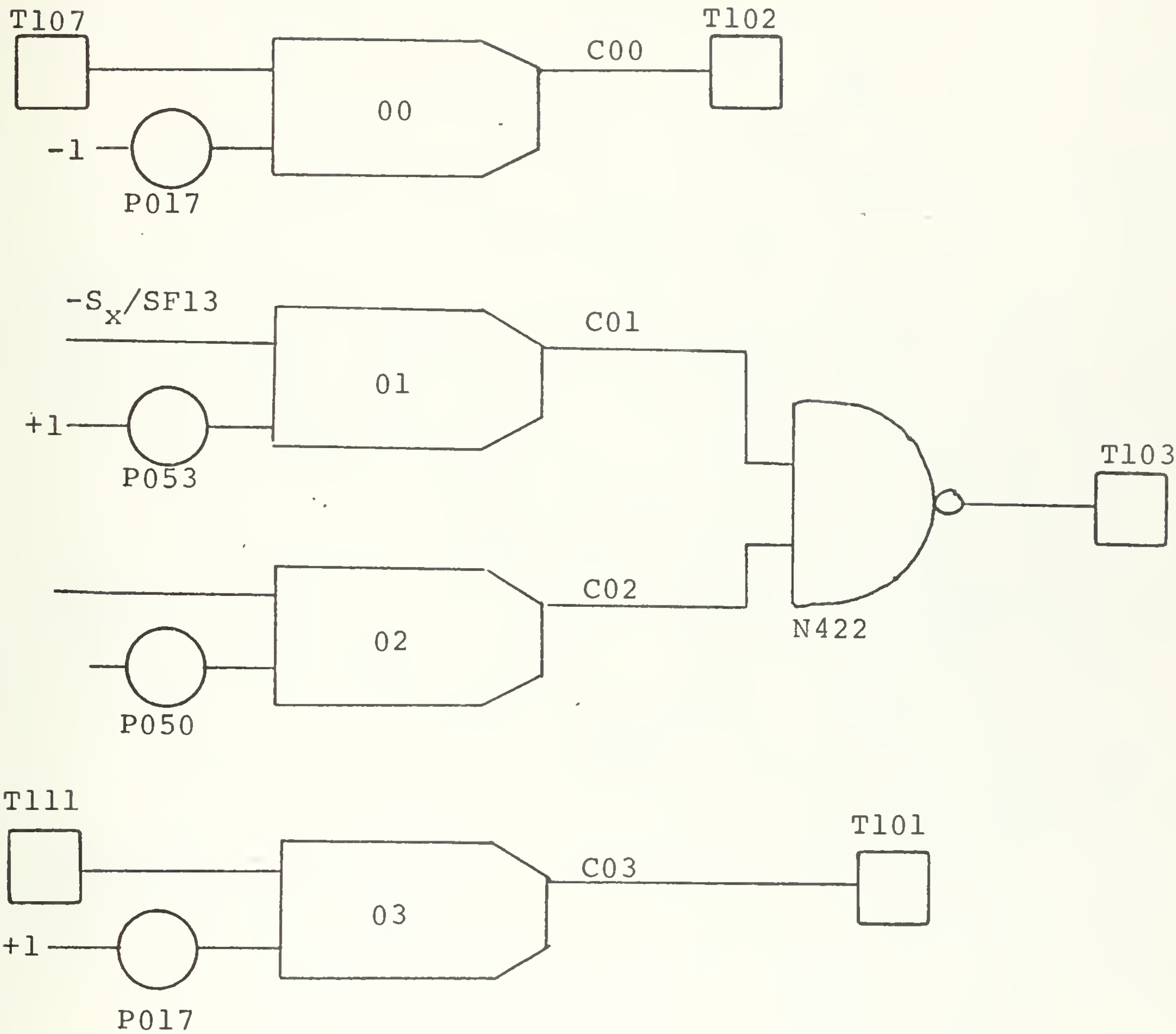


DPDT SWITCHES

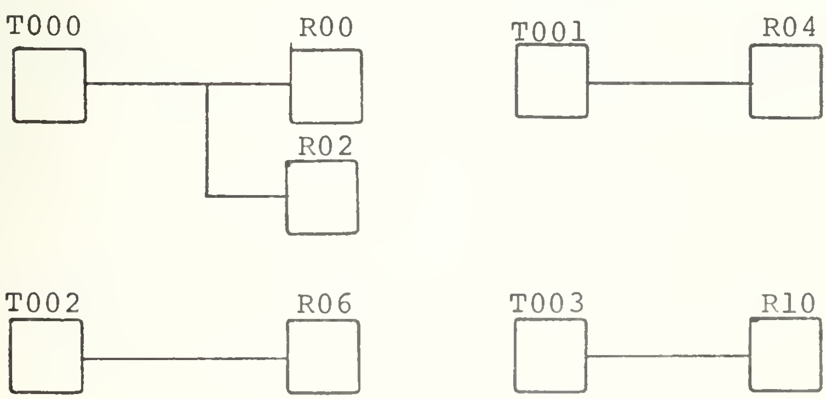


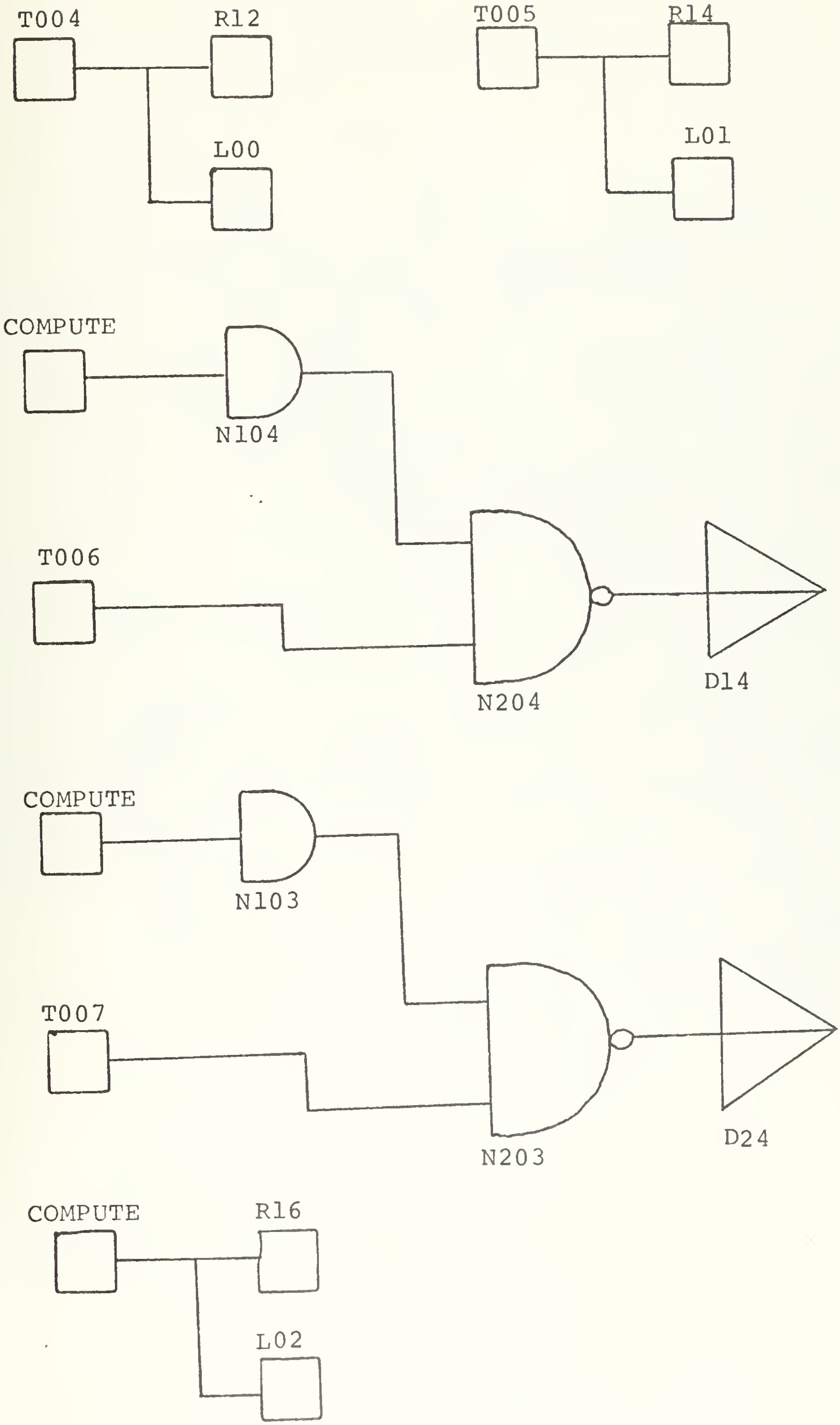

T101
TM
1
1
A013
-1
P013
P014
10
A015
TM/SF7
T510
T105
δit
1
1
A005
+1
P015
P034
10
1
A024
δit/SF16
T511
+1
δit_o
P044
T106
δa
1
1
A043
+1
P036
P035
10 A026
δa/SF17
T512
T104
δr
1
1
A042
+1
P040
P037
10
1
A041
δr/SF18
T513
P043
R/SF6
10
A047
-δr/SF18

COMPARATORS

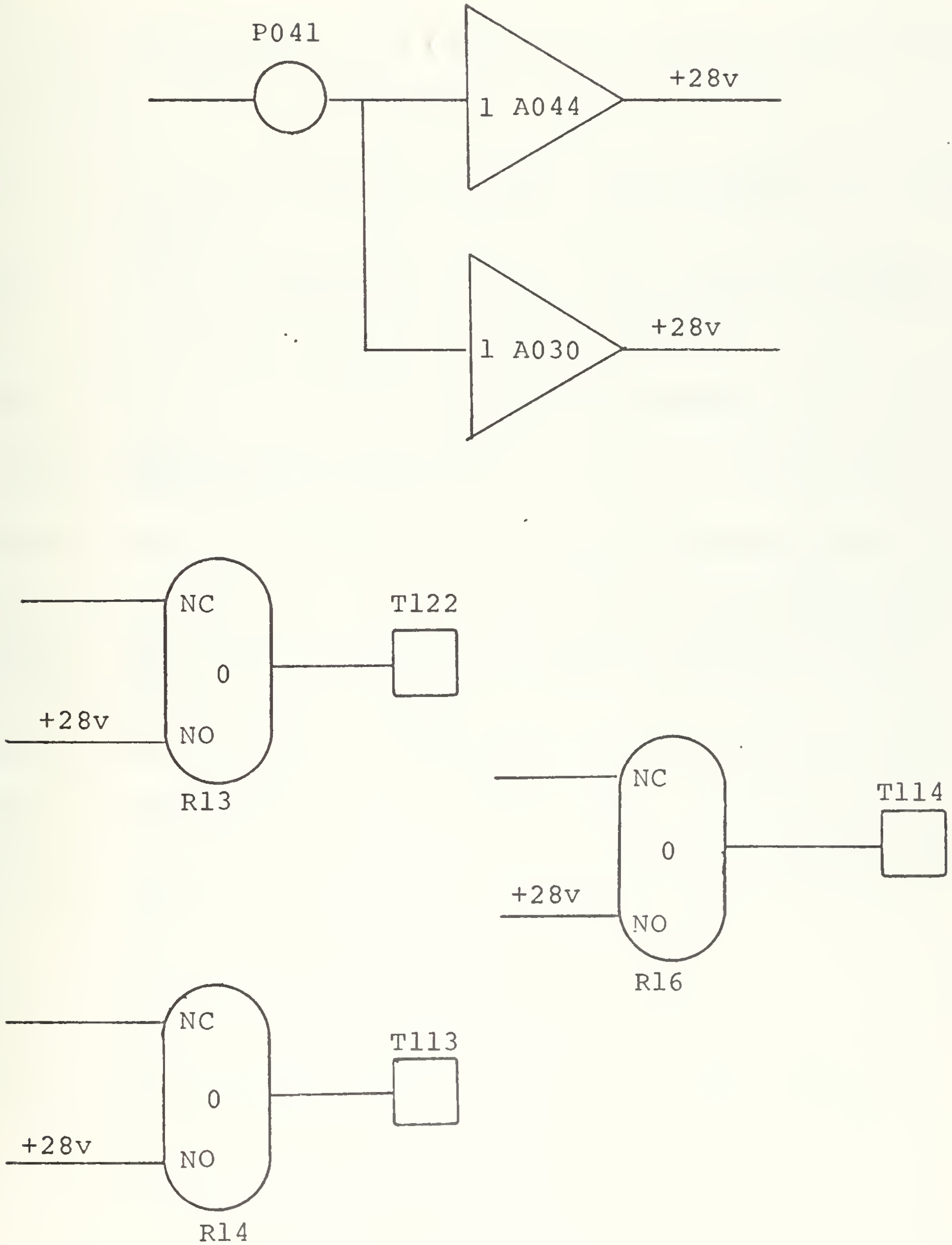


SETLINES




T004
R12
L00
T005
R14
L01
COMPUTE
N104
T006
N204
D14
COMPUTE
N103
T007
N203
D24
COMPUTE
R16
L02

POWER FOR LIGHTS



APPENDIX C

PROGRAM VARIABLES

The following is an alphabetical listing of the program variables used in the computer program.

A	Array of angles, in order, alpha, beta, psi, theta and phi
A10	Initial conditions on A(1), the angle of attack
AA	Array of digital to analog variables
AD	Array of analog to digital variables
ADOTN	Array of the negatives of the time derivatives of the angles in A
ADOTO	Old derivatives of angles in A used for prediction
ALI	Aerodynamic rolling moment about the body axis
ALPHA	Real argument based on angle of attack used for coefficient lookup
AMI	Aerodynamic pitching moment about the body axis
ANI	Aerodynamic yawing moment about the body axis
ARG	Argument used during sine and cosine lookup (type real)
B	Wing span
B2	One half the wing span B
BETA	Real argument based on sideslip angle used in coefficient lookup
BX	A measure of sideslip angle used in the generation of the "ball"
C	Array of aerodynamic coefficients for a given angle of attack and sideslip angle
CA	Array of cosines of the angle array A

CB	Mean aerodynamic chord
CB2	One half the mean aerodynamic chord CB
CCA(n)	Scalar equivalents of the array CA
CHOYC	Choice of program options offered by main program
COEFA	Array of coefficients dependent on angle of attack only
COEFAB	Array of coefficients dependent on angle of attack and sideslip angle
COF(n)	Summation variables used in the interpolation process of coefficient lookup
CON1	Program constant equal to the number of degrees in a radian
DA	Aileron deflection
DEGA	Degrees of angle of attack for which COEFA and COEFAB are tabulated
DEGB	Degrees of sideslip for which COEFAB are tabulated
DIT	Flying tail deflection
DITO	Initial flying tail deflection setting
DIV	Scale factor divisor used to divide out the scale factor of the homogeneous transformation coordinates
DR	Rudder deflection
F	Focal length of viewing image
FXAM	Aerodynamic force in the X-direction divided by the mass of the aircraft
FXSM	Force in X-direction of the stability axis divided by the mass of the aircraft
FYAM	Aerodynamic force in the Y-direction divided by the mass of the aircraft
FYSM	Force in the Y-direction of the stability axis divided by the mass of the aircraft
FYWM	Force in the Y-direction of the wind axis divided by the mass of the aircraft

FZAM	Aerodynamic force in the Z-direction divided by the mass of the aircraft
FZWM	Force in the Z-direction of the wind axis divided by the mass of the aircraft
G	Acceleration due to gravity
GEE	Scaled acceleration due to gravity
HINSCT	Horizontal intersection of a line, used in the software window
HM	Viewing plane orientation matrix for the horizon
I	Integer variable usually a counter
IA	Do-loop counter based on angle of attack
IAGN	A counter to check the number of times a point has gone through the software window
IALPHA	Integer conversion of ALPHA
IARG	Integer conversion of ARG
IB	Do-loop counter based on the sideslip angle
IBETA	Integer conversion of BETA
ICHOYC	Integer conversion of CHOYC
IDE	Graphic array containing the dynamic portion of the display
IDEV	Graphic device number (1 or 2)
IDIR	Graphic block directory for the graphics digital processor
IER	Error flag returned by graphic subroutines
IPLS	Integer counter equal to I plus one
ISF7	Integer scale factor based on thrust divided by mass
ISQ	Array/graphics block of fixed data, basically the square or window
ITDIR	Text directory for the graphics digital processor
ITEXnn	Line of text that is sent from the digital computer to the graphic digital processor

IX	Operating values of start/end points (X-coordinate) used in software window
IX1	Equivalent of XSTART, used in software window
IX2	Equivalent of XEND, used in software window
IY	Operating values of start/end points (Y-coordinate) used in software window
IY1	Equivalent of YSTART, used in software window
IY2	Equivalent of YEND, used in software window
J	Do-loop counter
K	Do-loop counter
KK	Array of integers used in outputing coefficients
KPOT	Array of integers used in outputing analog pot settings
LTR	Clock variable used in loop timing
NAD	Number of analog to digital conversion variables/ truck lines
NDA	Number of digital to analog conversion variables/ truck lines
NULL	Octal value used to null out a line of text
NUM	Variable used for program flow and control
P	Angular velocity of the aircraft about X-axis
PB	P normalized
PDOTN	The negative of the time derivative of P
POT	Array of pot settings for the analog
PS	P about the stability axis
Q	Angular velocity of the aircraft about the Y-axis
QB	Q normalized
QDOTN	The negative of the time derivative of Q
QS	Q about the stability axis
QUE	Dynamic pressure

R	Angular velocity about the Z-axis
RB	R normalized
RDOTN	The negative of the time derivative of R
RHO	Density of air
RIXX	Moment of inertia of the aircraft about the X-axis
RIXZ	Product of inertia about the X and Z-axis
RIYY	Moment of inertia of the aircraft about the Y-axis
RIZZ	Moment of inertia of the aircraft about the Z-axis
RMASS	Mass of the aircraft
RS	R about the stability axis
RT	Graphic transformation matrix or array
S	Wing area of the aircraft
SA	Array of sines of the angle array A
SDOT	Array of time derivatives (velocities) of the distances in all three inertial directions
SF	Product of the scale factor and focal length
SF1	Scale factor based on maximum velocity in X-direction
SF2	Scale factor based on maximum velocity in Y-direction
SF3	Scale factor based on maximum velocity in Z-direction
SF4	Scale factor based on maximum angular velocity in X-direction
SF5	Scale factor based on maximum angular velocity in Y-direction
SF6	Scale factor based on the maximum angular velocity in the Z-direction
SF7	Scale factor based on thrust divided by mass of the aircraft
SF8	Scale factor based on maximum angle of attack

SF9	Scale factor based on the maximum sideslip angle
SF10	Scale factor based on the maximum yaw angle
SF11	Scale factor based on the maximum pitch angle
SF12	Scale factor based on the maximum roll angle
SF13	Scale factor based on the maximum distance in the X-direction
SF14	Scale factor based on the maximum distance in the Y-direction
SF15	Scale factor based on the maximum distance in the Z-direction
SF16	Scale factor based on the maximum flying tail deflection angle
SF17	Scale factor based on the maximum aileron deflection angle
SF18	Scale factor based on the maximum rudder deflection angle
SF19	Scale factor based on the density of air
SF20	Scale factor based on SF1 squared divided by SF19
SF21	Ratio of SF6 to SF4
SF22	Ratio of SF1 to SF4
SF23	Ratio of SF1 to SF5
SF24	Ratio of SF1 to SF6
SF25	Ratio of SF4 to SF5
SF26	Ratio of SF5 to SF6
SF27	SF4 squared
SF28	SF5 squared
SF29	SF6 squared
SF30	Feedback gain for yaw damper
SF31	Scale factor based on SF7 divided by SF1 and SF5
SF32	Scale factor based on SF7 divided by SF1 and SF6

SF33	Ratio of SF1 to SF2
SF34	Ratio of SF1 to SF3
SF35	Scale factor based on ratio of SF5 to SF8
SF36	Scale factor based on ratio of SF6 to SF9
SF37	Scale factor based on ratio of SF6 to SF10
SF38	Scale factor based on ratio of SF6 to SF11
SF39	Scale factor based on ratio of SF6 to SF12
SF40	Ratio of SF7 to SF1
SFA	Array of scale factors, made up of SF8 thru SF12
SFACTOR	Scale factor of the H-Matrix
SK	Variable indicating portion of each line to be removed from display in the window chop loop
SLOPE	Slope of a display line, used in software window
SN	Negative of the scale factor
SSAn	Scalar equivalents of SA
SX	Actual distance of aircraft in X-direction (inertial)
SXO	Initial condition on SX
SXN	Normalized distance of aircraft in X-direction (inertial)
SY	Actual distance of aircraft in Y-direction (inertial)
SYN	Normalized distance of aircraft in Y-direction (inertial)
SZ	Actual distance of aircraft in Z-direction (inertial)
SZO	Initial condition on SZ
SZF	Final cutoff value on SZ (10,000 ft.)
SZN	Normalized distance of aircraft in Z-direction (inertial)
T	Thrust of the aircraft

TAU	Time delay for the prediction and update
TLINE	Array of the earth grid reference points
TM	Thrust divided by mass of aircraft
TRIG	Array of sines of various angles
TRIGC	Array of cosines of various angles
TX	A measure of roll angle in the X-direction used in generation of the "needle"
TY	A measure of roll angle in the Y-direction used in generation of the "needle"
V	Velocity
VO	Initial condition on velocity V
VDOT	Time derivative of V
VDOTO	VDOT of the iteration before
VINSCT	Vertical intersection of a line used in window
VX	Velocity in the X-direction
VY	Velocity in the Y-direction
VZ	Velocity in the Z-direction
W	Weight of the aircraft
X	X value used in software window
XEND	Array of X-coordinate ending points of display lines
XSTART	Array of X-coordinate starting points of display lines
XTE	X-coordinate ending point for the horizon
XTEMP	Temporary storage for X
XTS	X-coordinate starting point for the horizon
Y	Y value used in software window
YEND	Array of Y-coordinate ending points of display lines
YSTART	Array of Y-coordinate starting points of display lines

YTE	Y-coordinate ending point for the horizon
YTEMP	Temporary storage for Y-coordinate in software window
YTS	Y-coordinate starting point for the horizon
ZEND	Array of Z-coordinate ending points of display lines
ZSTART	Array of Z-coordinate starting points of display lines
ZTE	Z-coordinate ending point for the horizon
ZTS	Z-coordinate starting point for the horizon

APPENDIX D

DATA DECK PREPARATION

The following is a guide for use in preparing a data deck for use with the simulator.

Cards 1 - 3 - These cards contain the inputed scale factors as defined in Appendix C. Each scale factor has a field width of ten and are ordered as follows:

Card 1 - SF1, SF2, SF3, SF4, SF5, SF6, SF8, SF9

Card 2 - SF10, SF11, SF12, SF13, SF14, SF15, SF16, SF17

Card 3 - SF18, SF19, SF30, the remaining columns are blank

Card 4 - This card contains the initial conditions of the problem. Each number has a field width of ten and they are ordered as follows: initial X-coordinate (SXO) in feet, initial altitude (SZO) in feet, initial velocity (VO) in ft/sec, initial angle of attack (A10) in degrees, initial elevator angle (DITO) in degrees and the density of the air (RHO) in slug/ft^3. The remaining portion of the card is blank.

Cards 5 and 6 - These cards contain the aircraft constants. Each constant has a field width of ten and they are ordered as follows:

Card 5 - Weight (W) of aircraft in lb., wing span (B) in ft., wing chord (CB) in ft., wing area (S) in ft., moment of inertia about X-axis (RIXX) in slug-ft^2, moment of inertia about the Y-axis

(RIYY) in slug-ft^2, moment of inertia about the Z-axis (RIZZ) in slug-ft^2, and the cross product of inertia (RIXZ) in slug-ft^2.

Card 6 - Maximum thrust (T) in lbs., altitude cutoff (SZF) in feet. The remaining columns are left blank.

Cards 7 - 412 - These cards contain the aerodynamic coefficients dependent on both alpha and beta. The first card in each of a sequence of 135 three card series is as follows: in columns 1 and 2 the coefficient number, columns 3 and 4 blank, column 5 the index on beta (IB), columns 6-10 blank. The remaining portion of the card is filled with coefficients indexed on alpha (IA) in ten column intervals. The second and third cards in the series contain the remaining coefficients in ten column intervals and indexed on alpha. Alpha is indexed 19 times for each beta index while beta is indexed 9 times for each of the fifteen coefficients. The range on alpha is 0 - 90 degrees with 5 degree intervals while the range on beta is -40 degrees to +40 degrees with 10 degree intervals. The coefficients are as follows:

Number	Coefficient
1	C_l
2	C_m
3	C_n
4	C_Y
5	C_X

Number	Coefficient
6	C_Z
7	$C_{Z_{\delta it}}$
8	$C_{m_{\delta it}}$
9	$C_{Y_{\delta r}}$
10	$C_{l_{\delta r}}$
11	$C_{n_{\delta r}}$
12	$C_{Y_{\delta a}}$
13	$C_{l_{\delta a}}$
14	$C_{n_{\delta a}}$
15	$C_{X_{\delta it}}$

Cards 413 - 431 - These cards contain the aerodynamic coefficients dependent only on alpha. The first card in each of a sequence of 6 three card series is as follows: columns 1 and 2 the coefficient number, columns 3-10 blank, columns 11-80 the coefficients indexed on alpha and in ten column intervals. The second and third cards contain the remaining coefficients again in ten column intervals and indexed on alpha. The coefficients are as follows:

Number	Coefficient
16	C_{Y_p}
17	C_{l_p}
18	C_{n_p}
19	C_{Y_r}
20	C_{l_r}
21	C_{n_r}

Cards 432-440 - These cards also contain aerodynamic coefficients based on alpha only. The only difference in the setup of these cards in the field width is increased to eleven. As a result the first card in the series is as follows: columns 1 and 2 the coefficient number, column 3 blank, columns 4-80 contain the coefficients indexed on alpha and in eleven column intervals. The second and third cards contain the remaining coefficients indexed on alpha and in eleven column intervals. The coefficients are as follows:

Number	Coefficient
22	C_{Z_q}
23	C_{m_q}
24	C_{X_q}

Cards 440 -454 - These cards contain the actual coordinates for each line of the earth grid reference system. Each card represents one line with its starting and ending coordinates. On each card the first eight columns are the starting X-coordinate, columns 9-16 the starting Y-coordinate, columns 17-24 the starting Z-coordinate, columns 25-32 the homogeneous coordinate W, columns 33-40 the ending X-coordinate, columns 41-48 the ending Y-coordinate, columns 49-56 the ending Z-coordinate, and columns 57-64 the homogeneous coordinate W. The remainder of the card is left blank.

APPENDIX F

OPERATING MANUAL

Two tapes are available for use in execution of the digital program. One tape (labeled SPIN SIMULATOR SI) requires approximately 15 minutes to compile prior to execution. The second tape (labeled SPIN SIMULATOR CD), which is a core dump of the first tape, requires only 10 seconds prior to execution. It is recommended that the second tape be used due to its short compilation time unless a printed output of the program is desired.

All of the required cards, both control and data, are located in the laboratory files under FIXED-BASE SPIN SIMULATOR. Also filed here is the master card version of the program and should not be used unless the tapes are destroyed.

Detailed operating instructions for both the hybrid and graphics computers are available in the laboratory office. The following instructions should be followed in order to insure that the simulator is set up and executing properly.

1. Load the tape selected on the tape drives. Select the proper mount (2 for SI, 3 for CD).
2. Load and ready the card reader with control cards followed by the DATA.
3. Ready the Line Printer.
4. On the Digital Main Frame, Punch IDLE, RESET, RUN, CARDS.

5. Load the Analog Program board and the Analog Logic board into the computer (Boards number 7).

6. On the Analog Keyboard punch KEYBOARD, LOCAL, POTSET. In the far right control box, only the following can be lit: IDCX1 or IDCS.1 and REAL TIME. All other lights must be punched out. When complete punch DIGITAL CMPTR.

7. On the Analog the following options exist:

   DS0 - UP - no printed output

   CENTER - printed output

   DS1 - UP - distance integrators disabled

   CENTER - distance integrators enabled

   DS2 - UP - yaw damper ON

   CENTER - yaw damper OFF

   DOWN positions on these switches are mementary contact positions.

8. At the Graphics terminal teletype to be used, load the controling program by typing

   RESET ("GATD1", 104) !

   Then execute the program by typing GATED! At this point nothing should be on the display screen.

9. By this time the Digital computer should have compiled and loaded the main program and the following will be typed out on the digital consol teletype:

   INPUT AGT NUMBER

   The input light will then come on. To respond, type the AGT number (1 or 2) of the unit being used, followed by a carriage return.

10. The Title should appear on the selected AGT.
11. The Data will be read in from the card reader.
12. If output is selected, the output will be printed on the line printer.
13. The Analog Pots will be set by the Digital computer. The Address and Ratiometer readings should be changing.
14. Set the cockpit in front of the AGT (will only reach to AGT-2). The cockpit is stored behind the Analog computer.
15. The Instructions should flash on the screen.
16. Punch the button on the Throttle plate and the display will appear.
17. Punch the button on the control stick to fly. If during a run you wish to abort that run, punch the button on the Throttle plate.
18. At the completion of the run the Spin Results will be displayed, followed by a short delay in which to read them.
19. At this time two options are offered. To fly again punch the button on the Control stick and the program jumps back to the Instructions (#15).
20. To receive the expanded program options, punch the Throttle button. Follow the displayed instructions and type your selection on the AGT teletype unit. This will result in one of three things happening.

1. Logical STOP to the program.

2. Jump to the Instructions (#15).

3. Jump to the selection of the AGT number (#9).

21. At the completion of the computer time, return all used equipment (cards, tape, boards, cockpit) to their storage locations.

APPENDIX F

SAMPLE OUTPUT

The following is a sample output of the digital program which contains the following sections:

1. Scale Factors and Aircraft Constants
2. Original Aircraft Aerodynamic Coefficients
3. Usable Aircraft Aerodynamic Coefficients
4. Pot Settings for the Analog Computer
5. Output of the Amplifiers and D/A Trunks
6. Earth Grid Reference Lines

```
SF1  =   1053.630          SF30 =       1.000
SF2  =   1053.630          SF31 =        .012
SF3  =   1053.630          SF32 =        .009
SF4  =      3.150          SF33 =       1.000
SF5  =      3.150          SF34 =       1.000
SF6  =      4.210          SF35 =       1.559
SF7  =     40.000          SF36 =       5.092
SF8  =    115.790          SF37 =        .603
SF9  =     47.370          SF38 =       1.206
SF10 =    400.000          SF39 =        .603
SF11 =    200.000          SF40 =        .038
SF12 =    400.000
SF13 =  52631.580          SXO  =    6000.000
SF14 =  52631.580          SZO  =   30000.000
SF15 =  52631.580          VO   =     622.000
SF16 =     22.050          A10  =       5.000
SF17 =     12.630          DITO =      -2.268
SF18 =     22.050          RHθ  =      .00126
SF19 =    750.000
SF20 =    740.091
SF21 =      1.337          W    =   50039.000
SF22 =    334.486          B    =      63.000
SF23 =    334.486          CB   =       9.000
SF24 =    250.268          S    =     525.000
SF25 =      1.000          RIXX =   53100.000
SF26 =       .748          RIYY =  299000.000
SF27 =      9.922          RIZZ =  338750.000
SF28 =      9.922          RIXZ =   12480.000
SF29 =     17.724          T    =   50000.000
SZF  =  10000.000
```

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 1

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0436400	.0320200	.0204000	.0087800	.0000000	-.0144600	-.0260800	-.0377000	-.0493200
5.0	.0718950	.0535150	.0351350	.0167550	.0000000	-.0200050	-.0383850	-.0567650	-.0751450
10.0	.1001500	.0750100	.0498700	.0247300	.0000000	-.0255500	-.0506900	-.0758300	-.1009700
15.0	.0901400	.0670300	.0439200	.0208100	.0000000	-.0254100	-.0485200	-.0716300	-.0947400
20.0	.0801300	.0590500	.0379700	.0168900	.0000000	-.0252700	-.0463500	-.0674300	-.0885100
25.0	.0787100	.0508750	.0247950	.0061500	-.0035800	-.0216900	-.0260150	-.0559450	-.0797250
30.0	.0772900	.0427000	.0116200	-.0045900	-.0071600	-.0181100	-.0056800	-.0444600	-.0709400
35.0	.0630000	.0429700	.0163500	-.0047300	-.0156700	-.0141900	-.0120300	-.0439200	-.0683700
40.0	.0524300	.0429700	.0208100	-.0051300	-.0209400	-.0105400	-.0186500	-.0435100	-.0660800
45.0	.0733700	.0432400	.0271600	.0059500	-.0104000	-.0101300	-.0283800	-.0532400	-.0728300
50.0	.0781000	.0409400	.0278400	.0121600	-.0041900	-.0112200	-.0281100	-.0527000	-.0654000
55.0	.0831000	.0668900	.0471600	.0205400	.0012200	-.0227000	-.0468900	-.0563500	-.0787800
60.0	.0828300	.0675600	.0504000	.0244600	.0025700	-.0232400	-.0510800	-.0687800	-.0820200
65.0	.0836400	.0667500	.0545900	.0264800	.0006800	-.0267500	-.0500000	-.0685100	-.0827000
70.0	.0871600	.0663500	.0470200	.0277000	.0013500	-.0255400	-.0472900	-.0650000	-.0843200
75.0	.0862800	.0656750	.0454000	.0269550	-.0009450	-.0243900	-.0462800	-.0656750	-.0839800
80.0	.0854000	.0650000	.0437800	.0262100	-.0032400	-.0232400	-.0452700	-.0663500	-.0836400
85.0	.0852650	.0636450	.0457400	.0265500	.0005400	-.0239150	-.0463500	-.0643900	-.0828300
90.0	.0851300	.0622900	.0477000	.0268900	.0043200	-.0245900	-.0474300	-.0624300	-.0820200

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 2

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0573800	.0573800	.0573800	.0573800	.0573800	.0573800	.0573800	.0573800	.0573800
5.0	-.0795200	-.0795200	-.0795200	-.0795200	-.0795200	-.0795200	-.0795200	-.0795200	-.0795200
10.0	-.2164200	-.2164200	-.2164200	-.2164200	-.2164200	-.2164200	-.2164200	-.2164200	-.2164200
15.0	-.2699550	-.2699550	-.2699550	-.2699550	-.2699550	-.2699550	-.2699550	-.2699550	-.2699550
20.0	-.3234900	-.3234900	-.3234900	-.3234900	-.3234900	-.3234900	-.3234900	-.3234900	-.3234900
25.0	-.1999450	-.2397300	-.3949900	-.3678050	-.5092500	-.4476200	-.4157600	-.3593400	-.0364000
30.0	-.0764000	-.1559700	-.4664900	-.4121200	-.6950100	-.5717500	-.5080300	-.3951900	.2506900
35.0	.1195400	-.1779300	-.4617000	-.5036200	-.7608800	-.6148700	-.5265600	-.3554000	.0655800
40.0	.3259100	-.1998800	-.4464900	-.5917100	-.7688400	-.6545800	-.5346700	-.3015900	-.1161100
45.0	-.0163000	-.0202600	-.3248900	-.6301500	-.8302700	-.6855300	-.3281500	-.4625900	-.3360700
50.0	-.1774500	.0366500	-.3454200	-.6699400	-.8795400	-.6906300	-.3659500	-.5450300	-.2131900
55.0	-.3156000	-.2604400	-.7585300	-.8128800	-.9392400	-.8400900	-.4290700	-.5529900	-.4880600
60.0	-.6817600	-.4157000	-.3910100	-1.0083000	-1.0582000	-.9124300	-.6020700	-.7079300	-.5470300
65.0	-.7687300	-.6596100	-.5181100	-1.1249000	-1.1203000	-.9336000	-1.0127000	-.9098300	-.6266900
70.0	-.6986200	-1.1048000	-1.2190000	-1.0711000	-1.2366000	-1.2100000	-1.4056000	-.9728500	-.7338800
75.0	-.8360550	-1.1994500	-1.4012500	-1.3943500	-1.5118000	-1.4571000	-1.4841000	-1.0765250	-.8458100
80.0	-.9734900	-1.2941000	-1.5835000	-1.7176000	-1.7870000	-1.7042000	-1.5626000	-1.1802000	-.9577400
85.0	-1.0966950	-1.4203500	-1.6702000	-1.8562500	-2.0285500	-1.8511000	-1.6720500	-1.3222500	-1.0195700
90.0	-1.2199000	-1.5466000	-1.7569000	-1.9949000	-2.2701000	-1.9980000	-1.7815000	-1.4643000	-1.0814000

ØRIGINAL CØEF ARRAY

COEFFICIENT NUMBER 3

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0543700	-.0408500	-.0273300	-.0138100	.0000000	.0132300	.0267500	.0402700	.0537900
5.0	-.0470350	-.0354800	-.0239150	-.0123500	.0000000	.0107800	.0223450	.0339100	.0454750
10.0	-.0397200	-.0301100	-.0205000	-.0108900	.0000000	.0083300	.0179400	.0275500	.0371600
15.0	-.0228350	-.0176300	-.0124150	-.0072000	.0000000	.0032300	.0084450	.0136600	.0188750
20.0	-.0059700	-.0051500	-.0043300	-.0035100	.0000000	-.0018700	-.0010500	-.0002300	.0005900
25.0	.0220150	.0137100	.0200200	.0086700	-.0029200	-.0230000	-.0226850	-.0260850	-.0217900
30.0	.0500000	.0325700	.0443700	.0208500	-.0058400	-.0441300	-.0443200	-.0519400	-.0441700
35.0	.0526500	.0399800	.0380700	.0362700	-.0071500	-.0590800	-.0472900	-.0573400	-.0612600
40.0	.0548700	.0471100	.0314900	.0514000	-.0161100	-.0747400	-.0505500	-.0631700	-.0783500
45.0	.0604700	.0342500	.0068500	.0270100	-.0248000	-.0675700	-.0087000	-.0644500	-.0846000
50.0	.0539800	.0169500	-.0098200	-.0268800	-.0334900	-.0201100	.0009100	-.0619100	-.0853800
55.0	.0385500	-.0018700	-.0370300	-.0254300	.0078900	.0219800	.0152500	-.0496200	-.0655500
60.0	.0417100	-.0254300	-.0502600	.0176700	.0864900	.0350400	.0136800	-.0308100	-.0508200
65.0	.0295700	-.0288700	-.0625600	-.0076200	.0831200	.0589200	-.0248100	-.0282200	-.0405600
70.0	-.0068500	-.0064900	.0135200	-.0522600	-.0417400	-.0219700	-.0793000	-.0035100	-.0261100
75.0	-.0150300	-.0268850	.0132750	-.0285050	-.0157400	-.0118100	-.0453350	.0192650	-.0091200
80.0	-.0232100	-.0472800	.0130300	-.0047500	.0102600	-.0016500	-.0113700	.0420400	.0078700
85.0	-.0224350	-.0211300	.0032400	-.0030300	.0026800	.0010850	.0037550	.0251250	.0140250
90.0	-.0216600	.0050200	-.0065500	-.0013100	-.0049000	.0038200	.0188800	.0082100	.0201800

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 4

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.5307600	.3980700	.2653800	.1326900	.0000000	-.1326900	-.2653800	-.3980700	-.5307600
5.0	.5479500	.4128050	.2774100	.1425150	.0000000	-.1277750	-.2629200	-.3980650	-.5197100
10.0	.5651400	.4275400	.2899400	.1523400	.0000000	-.1228600	-.2604600	-.3980600	-.5356600
15.0	.5454900	.4152600	.2847800	.1548000	.0000000	-.1056600	-.2358900	-.3661200	-.4963500
20.0	.5258400	.4029800	.2801200	.1572600	.0000000	-.0884600	-.2113200	-.3341800	-.4570400
25.0	.5282950	.3956050	.2727450	.1351450	.0270300	-.0565150	-.1769200	-.3145200	-.4324650
30.0	.5307500	.3882300	.2653700	.1130300	.0540600	-.0245700	-.1425200	-.2948600	-.4078900
35.0	.5602300	.4128000	.3046900	.1720000	.0491400	-.0589700	-.1916600	-.3292600	-.4275500
40.0	.5946300	.4373800	.3440000	.2309700	.0491400	-.0884600	-.2408000	-.3587500	-.4472000
45.0	.5700600	.5356600	.3980600	.2555500	.0393100	-.1277700	-.2899500	-.4373800	-.4717800
50.0	.5749800	.5651500	.4570300	.2801200	.0294900	-.1916600	-.3341700	-.4766900	-.5061800
55.0	.5995500	.5454900	.4373800	.2801200	.0491400	-.1769200	-.3194300	-.4717800	-.4914300
60.0	.5897200	.5504000	.3931500	.2899500	.1130300	-.1474300	-.3046900	-.4619500	-.5012600
65.0	.5897200	.5700600	.3882300	.2948600	.0884600	-.1326900	-.3243500	-.4717800	-.5061800
70.0	.5995500	.5553200	.5012600	.2260600	.0245700	-.1769200	-.4128000	-.4766900	-.5061800
75.0	.5921800	.5454900	.4840600	.2555450	.0098300	-.1990300	-.4177150	-.4742350	-.5037200
80.0	.5848100	.5356600	.4668600	.2850300	-.0049100	-.2211400	-.4226300	-.4717800	-.5012600
85.0	.5725200	.5258300	.4447450	.2752000	.0024600	-.2260550	-.4103450	-.4717800	-.4938900
90.0	.5602300	.5160000	.4226300	.2653700	.0098300	-.2309700	-.3980600	-.4717800	-.4865200

ØRIGINAL CØEF ARRAY

CØEFFICIENT NUMBER 5

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0547500	-.0547500	-.0547500	-.0547500	-.0547500	-.0547500	-.0547500	-.0547500	-.0547500
5.0	-.0393900	-.0393900	-.0393900	-.0393900	-.0393900	-.0393900	-.0393900	-.0393900	-.0393900
10.0	-.0240400	-.0240400	-.0240400	-.0240400	-.0240400	-.0240400	-.0240400	-.0240400	-.0240400
15.0	-.0260400	-.0260400	-.0260400	-.0260400	-.0260400	-.0260400	-.0260400	-.0260400	-.0260400
20.0	-.0280400	-.0280400	-.0280400	-.0280400	-.0280400	-.0280400	-.0280400	-.0280400	-.0280400
25.0	-.0206900	-.0267000	-.0300500	-.0320500	-.0240400	-.0267000	-.0353800	-.0298800	-.0220300
30.0	-.0133500	-.0253700	-.0320500	-.0360500	-.0200300	-.0253700	-.0427300	-.0347200	-.0160200
35.0	.0080100	-.0173600	-.0213700	-.0240400	-.0173600	-.0240400	-.0320500	-.0200300	-.0040100
40.0	.0280400	.0026700	-.0133500	-.0146900	-.0133500	-.0240400	-.0227000	-.0080100	.0053400
45.0	.0227000	.0227000	-.0013400	-.0120200	-.0187000	-.0200300	.0000000	-.0013400	.0053400
50.0	.0267100	.0333800	.0080100	-.0200300	-.0200300	-.0133500	.0146900	.0146900	.0253700
55.0	.0373900	.0280400	.0106800	-.0106800	-.0120200	.0000000	.0280400	.0267100	.0280400
60.0	.0280400	.0293800	.0320500	.0120200	.0200300	.0200300	.0427300	.0387300	.0373900
65.0	.0387300	.0440700	.0494100	.0333800	.0387300	.0440700	.0414000	.0427300	.0467400
70.0	.0440700	.0414000	.0467400	.0360500	.0347200	.0387300	.0373900	.0494100	.0480700
75.0	.0494100	.0437400	.0460700	.0360500	.0380600	.0380600	.0420600	.0645900	.0574200
80.0	.0547500	.0560900	.0454000	.0360500	.0414000	.0373900	.0467400	.0747800	.0667700
85.0	.0574200	.0567600	.0540800	.0450300	.0474800	.0487400	.0614300	.0721100	.0714500
90.0	.0600900	.0574200	.0627600	.0534100	.0547500	.0600900	.0761200	.0694400	.0761200

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 6

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0579900	-.0579900	-.0579900	-.0579900	-.0579900	-.0579900	-.0579900	-.0579900	-.0579900
5.0	-.4349000	-.4349000	-.4349000	-.4349000	-.4349000	-.4349000	-.4349000	-.4349000	-.4349000
10.0	-.8118200	-.8118200	-.8118200	-.8118200	-.8118200	-.8118200	-.8118200	-.8118200	-.8118200
15.0	-1.2235600	-1.2235600	-1.2235600	-1.2235600	-1.2235600	-1.2235600	-1.2235600	-1.2235600	-1.2235600
20.0	-1.6353000	-1.6353000	-1.6353000	-1.6353000	-1.6353000	-1.6353000	-1.6353000	-1.6353000	-1.6353000
25.0	-1.4845000	-1.6411000	-1.7338000	-1.8730000	-2.0818000	-1.9542000	-1.7512000	-1.6701000	-1.5367000
30.0	-1.3337000	-1.6468000	-1.8324000	-2.1107000	-2.5283000	-2.2731000	-1.8672000	-1.7164000	-1.4381000
35.0	-1.5193000	-1.7512000	-1.9832000	-2.2963000	-2.8414000	-2.4239000	-1.9716000	-1.7164000	-1.4613000
40.0	-1.6932000	-1.8556000	-2.1223000	-2.4819000	-2.9226000	-2.5746000	-2.0644000	-1.7860000	-1.4845000
45.0	-1.6932000	-1.9832000	-2.2383000	-2.5399000	-2.9110000	-2.5862000	-2.2267000	-1.7976000	-1.5541000
50.0	-1.7164000	-2.0760000	-2.2383000	-2.4471000	-2.7602000	-2.4587000	-2.2383000	-1.8208000	-1.5773000
55.0	-1.8092000	-2.0296000	-2.1687000	-2.3891000	-2.6210000	-2.3775000	-2.0992000	-1.9020000	-1.6584000
60.0	-1.8092000	-2.1223000	-2.3195000	-2.4123000	-2.5631000	-2.4123000	-2.2383000	-1.9716000	-1.7164000
65.0	-1.9136000	-2.1919000	-2.3543000	-2.4355000	-2.5978000	-2.4587000	-2.2383000	-1.9716000	-1.7860000
70.0	-2.0412000	-2.2151000	-2.3079000	-2.5051000	-2.5978000	-2.4007000	-2.1919000	-2.0760000	-1.8672000
75.0	-2.0817000	-2.2557000	-2.3717000	-2.4935000	-2.5746000	-2.4529000	-2.3021000	-2.1513000	-1.9194000
80.0	-2.1223000	-2.2963000	-2.4355000	-2.4819000	-2.5515000	-2.5051000	-2.4173000	-2.2267000	-1.9716000
85.0	-2.1223000	-2.2673000	-2.3949000	-2.4877000	-2.5746000	-2.4877000	-2.4065000	-2.2267000	-1.9890000
90.0	-2.1223000	-2.2383000	-2.3543000	-2.4935000	-2.5978000	-2.4703000	-2.4007000	-2.2267000	-2.0064000

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 7

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0194300	-.0194300	-.0194300	-.0194300	-.0194300	-.0194300	-.0194300	-.0194300	-.0194300
5.0	-.0199700	-.0199700	-.0199700	-.0199700	-.0199700	-.0199700	-.0199700	-.0199700	-.0199700
10.0	-.0205200	-.0205200	-.0205200	-.0205200	-.0205200	-.0205200	-.0205200	-.0205200	-.0205200
15.0	-.0204400	-.0204400	-.0204400	-.0204400	-.0204400	-.0204400	-.0204400	-.0204400	-.0204400
20.0	-.0203600	-.0203600	-.0203600	-.0203600	-.0203600	-.0203600	-.0203600	-.0203600	-.0203600
25.0	-.0128200	-.0165200	-.0167300	-.0201400	-.0267500	-.0239100	-.0158200	-.0159400	-.0186800
30.0	-.0052800	-.0126700	-.0131000	-.0199300	-.0331300	-.0274600	-.0112900	-.0115100	-.0170000
35.0	-.0042400	-.0066800	-.0114900	-.0179900	-.0300000	-.0237800	-.0097300	-.0102600	-.0113700
40.0	-.0031900	-.0006800	-.0098800	-.0160500	-.0268700	-.0201000	-.0081600	-.0090000	-.0057400
45.0	-.0022900	-.0035300	-.0071700	-.0119300	-.0219300	-.0142500	-.0086700	-.0060400	-.0042200
50.0	-.0013900	-.0063800	-.0044600	-.0078100	-.0169800	-.0083900	-.0091800	-.0030700	-.0027000
55.0	-.0004700	-.0069500	-.0076700	-.0081300	-.0155900	-.0087100	-.0083000	-.0053700	-.0035200
60.0	.0004600	-.0075200	-.0108800	-.0084400	-.0142000	-.0090300	-.0074100	-.0076600	-.0043400
65.0	-.0026800	-.0060000	-.0061700	-.0072200	-.0127100	-.0069700	-.0068400	-.0049600	-.0039800
70.0	-.0058200	-.0044800	-.0014500	-.0059900	-.0112200	-.0049000	-.0062700	-.0022500	-.0036200
75.0	-.0063700	-.0053300	-.0031600	-.0039300	-.0094700	-.0045600	-.0064600	-.0045400	-.0053400
80.0	-.0069300	-.0061800	-.0048700	-.0018800	-.0077200	-.0042200	-.0066600	-.0068300	-.0070700
85.0	-.0069300	-.0061800	-.0048700	-.0018800	-.0077200	-.0042200	-.0066600	-.0068500	-.0070700
90.0	-.0069300	-.0061800	-.0048700	-.0018800	-.0077200	-.0042200	-.0066600	-.0068800	-.0070700

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 8

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0349900	-.0349900	-.0349900	-.0349900	-.0349900	-.0349900	-.0349900	-.0349900	-.0349900
5.0	-.0350500	-.0350500	-.0350500	-.0350500	-.0350500	-.0350500	-.0350500	-.0350500	-.0350500
10.0	-.0351100	-.0351100	-.0351100	-.0351100	-.0351100	-.0351100	-.0351100	-.0351100	-.0351100
15.0	-.0363700	-.0363700	-.0363700	-.0363700	-.0363700	-.0363700	-.0363700	-.0363700	-.0363700
20.0	-.0376300	-.0376300	-.0376300	-.0376300	-.0376300	-.0376300	-.0376300	-.0376300	-.0376300
25.0	-.0256200	-.0234600	-.0272400	-.0319300	-.0391250	-.0351350	-.0282550	-.0291750	-.0160050
30.0	-.0136100	-.0092900	-.0168500	-.0262300	-.0406200	-.0326400	-.0188800	-.0207200	.0056200
35.0	-.0085600	-.0151100	-.0130100	-.0208100	-.0355000	-.0265400	-.0162400	-.0102100	.0082200
40.0	-.0035000	-.0209300	-.0091600	-.0153900	-.0303700	-.0204400	-.0135900	.0003000	.0108100
45.0	-.0012600	-.0070600	-.0090000	-.0112100	-.0226700	-.0150300	-.0097600	-.0008600	.0083500
50.0	.0009900	.0068200	-.0088300	-.0070200	-.0149700	-.0096200	-.0059200	-.0020100	.0058900
55.0	-.0088700	.0091100	.0059500	-.0047800	-.0078200	-.0036900	-.0031900	-.0027500	-.0014700
60.0	-.0187300	.0114000	.0207300	-.0025400	-.0006600	.0022400	-.0004500	-.0034900	-.0088200
65.0	-.0138900	-.0030800	.0047100	.0023000	.0018800	.0069400	.0000100	-.0070800	-.0100400
70.0	-.0090500	-.0175500	-.0113100	.0071300	.0044200	.0116300	.0004700	-.0106700	-.0112500
75.0	-.0088450	-.0118150	-.0114300	-.0005600	-.0011400	.0012300	-.0046050	-.0084300	-.0121300
80.0	-.0086400	-.0060800	-.0115500	-.0082500	-.0067000	-.0091700	-.0096800	-.0061900	-.0130100
85.0	-.0086400	-.0060800	-.0115500	-.0082500	-.0067000	-.0091700	-.0096800	-.0061900	-.0130100
90.0	-.0086400	-.0060800	-.0115500	-.0082500	-.0067000	-.0091700	-.0096800	-.0061900	-.0130100

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 9

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0048400	.0048400	.0048400	.0048400	.0048400	.0048400	.0048400	.0048400	.0048400
5.0	.0046400	.0046700	.0046700	.0046700	.0046700	.0046700	.0046700	.0046700	.0046700
10.0	.0045000	.0045000	.0045000	.0045000	.0045000	.0045000	.0045000	.0045000	.0045000
15.0	.0044900	.0044900	.0044900	.0044900	.0044900	.0044900	.0044900	.0044900	.0044900
20.0	.0044800	.0044800	.0044800	.0044800	.0044800	.0044800	.0044800	.0044800	.0044800
25.0	.0029900	.0027850	.0029900	.0036250	.0048100	.0026650	.0026200	.0022500	.0025350
30.0	.0015000	.0010900	.0015000	.0027700	.0051400	.0008500	.0007600	.0000200	.0005900
35.0	.0014800	.0005800	.0009800	.0021500	.0043100	.0013700	.0006200	-.0010500	.0010200
40.0	.0014600	.0000600	.0004500	.0015200	.0034700	.0018900	.0004800	-.0021100	.0014500
45.0	.0008000	.0005200	.0004200	.0005900	.0012300	.0007600	.0004300	-.0009900	.0010500
50.0	.0001400	.0009800	.0003800	-.0003400	-.0010200	-.0003800	.0003800	.0001300	.0006500
55.0	.0006300	.0006600	.0005600	-.0005100	-.0007000	-.0012200	-.0003000	.0006300	.0004700
60.0	-.0002000	.0006600	-.0012500	-.0006800	.0014300	-.0005800	.0001900	-.0000400	.0008100
65.0	.0003000	.0014800	-.0004100	.0016500	.0026100	.0007500	.0015400	-.0002100	.0003200
70.0	.0014600	.0013200	.0020200	.0018600	.0013200	.0016100	-.0000800	.0004600	.0004800
75.0	.0015500	.0015750	.0022000	.0023450	.0012450	.0013750	.0002600	.0007950	.0007300
80.0	.0016400	.0018300	.0023800	.0028300	.0011700	.0011400	.0006000	.0011300	.0009800
85.0	.0012300	.0015050	.0017250	.0021650	.0014150	.0003900	.0003400	.0003800	-.0000250
90.0	.0008200	.0011800	.0010700	.0015000	.0016600	-.0003600	.0000800	-.0003700	-.0010300

ØRIGINAL CØEF ARRAY

COEFFICIENT NUMBER 10

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0001700	.0001700	.0001700	.0001700	.0001700	.0001700	.0001700	.0001700	.0001700
5.0	.0001400	.0001400	.0001400	.0001400	.0001400	.0001400	.0001400	.0001400	.0001400
10.0	.0001100	.0001100	.0001100	.0001100	.0001100	.0001100	.0001100	.0001100	.0001100
15.0	.0001050	.0001050	.0001050	.0001050	.0001050	.0001050	.0001050	.0001050	.0001050
20.0	.0001000	.0001000	.0001000	.0001000	.0001000	.0001000	.0001000	.0001000	.0001000
25.0	.0000700	.0000350	.0001400	.0001350	.0001650	-.0003000	.0000350	-.0001000	.0001100
30.0	.0000400	-.0000300	.0001800	.0001700	.0002300	-.0007000	-.0000300	-.0003000	.0001200
35.0	-.0001300	.0000000	.0001300	.0002300	-.0000600	-.0002800	.0000600	-.0001100	.0001100
40.0	-.0002900	.0000300	.0000700	.0002900	-.0003500	.0001400	.0001500	.0000800	.0001000
45.0	-.0001200	-.0002100	.0000600	.0001100	-.0003100	.0000800	.0000800	.0000800	-.0000100
50.0	.0000600	-.0004400	.0000500	-.0000700	-.0002600	.0000200	.0000000	.0000080	-.0001200
55.0	.0000300	.0000200	.0001100	-.0000100	-.0000200	.0000700	.0000100	.0000900	.0000200
60.0	-.0000800	-.0001100	.0000700	.0000100	.0000400	.0000700	.0000100	.0000600	.0000700
65.0	-.0001000	.0000700	.0001000	.0000800	.0000900	-.0000500	-.0000500	.0000300	.0000400
70.0	.0000400	.0000500	.0000600	.0000800	.0000200	-.0000300	.0000500	.0000300	.0000500
75.0	.0000400	.0000200	.0000550	.0001250	-.0000350	.0000150	.0000500	.0000200	.0000450
80.0	.0000400	-.0000100	.0000500	.0001700	-.0000900	.0000600	.0000500	.0000100	.0000400
85.0	.0000100	.0000050	.0000650	.0001400	.0000300	.0000250	.0000100	.0000050	.0000350
90.0	-.0000200	.0000200	.0000800	.0001100	.0001500	-.0000100	-.0000300	.0000000	.0000300

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 11

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0013500	-.0013500	-.0013500	-.0013500	-.0013500	-.0013500	-.0013500	-.0013500	-.0013500
5.0	-.0013150	-.0013150	-.0013150	-.0013150	-.0013150	-.0013150	-.0013150	-.0013150	-.0013150
10.0	-.0012800	-.0012800	-.0012800	-.0012800	-.0012800	-.0012800	-.0012800	-.0012800	-.0012800
15.0	-.0012700	-.0012700	-.0012700	-.0012700	-.0012700	-.0012700	-.0012700	-.0012700	-.0012700
20.0	-.0012600	-.0012600	-.0012600	-.0012600	-.0012600	-.0012600	-.0012600	-.0012600	-.0012600
25.0	-.0008050	-.0008450	-.0006200	-.0011200	-.0012950	-.0011500	-.0007950	-.0006800	-.0003600
30.0	-.0003500	-.0004300	.0000200	-.0009800	-.0013300	-.0010400	-.0003300	-.0001000	.0005400
35.0	-.0003800	-.0001200	-.0001700	-.0000900	-.0013600	-.0009700	-.0005000	.0002000	.0004000
40.0	-.0004000	.0002000	-.0003500	.0008100	-.0013800	-.0008900	-.0006700	.0005000	.0002600
45.0	-.0003600	.0001200	-.0001300	-.0005400	-.0016900	-.0008400	-.0000700	.0004400	.0003000
50.0	-.0003100	.0000300	.0000900	-.0018800	-.0019900	-.0007900	.0005300	.0003800	.0003300
55.0	-.0002200	-.0007400	-.0012200	-.0024000	-.0012200	-.0003700	.0000800	.0001500	.0004100
60.0	.0005300	-.0015700	-.0027100	-.0015200	.0014800	-.0002400	.0005800	.0005500	.0000500
65.0	.0006500	-.0011300	-.0025700	-.0015500	.0024400	.0019200	.0018000	.0000000	-.0002000
70.0	-.0007000	.0000500	.0017600	.0000200	.0000300	.0020800	.0010400	-.0003900	-.0004300
75.0	-.0005850	.0002250	.0007350	-.0000750	.0001250	.0009900	.0004750	.0005100	-.0002150
80.0	-.0004700	-.0005000	-.0002900	-.0001700	.0002200	-.0001000	-.0000900	.0014100	.0000000
85.0	-.0003600	-.0004700	-.0003900	-.0001300	-.0000500	-.0000050	.0002400	.0007900	.0000300
90.0	-.0002500	-.0004400	-.0004900	-.0000900	-.0003200	.0000900	.0005700	.0001700	.0000600

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 12

BETA ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0015000	.0015000	.0015000	.0015000	.0015000	.0015000	.0015000	.0015000	.0015000
5.0	.0015100	.0015100	.0015100	.0015100	.0015100	.0015100	.0015100	.0015100	.0015100
10.0	.0015200	.0015200	.0015200	.0015200	.0015200	.0015200	.0015200	.0015200	.0015200
15.0	.0010350	.0010350	.0010350	.0010350	.0010350	.0010350	.0010350	.0010350	.0010350
20.0	.0005500	.0005500	.0005500	.0005500	.0005500	.0005500	.0005500	.0005500	.0005500
25.0	-.0020650	-.0039200	-.0035150	-.0018850	.0003150	.0007550	-.0018300	-.0004500	-.0010350
30.0	-.0046800	-.0083900	-.0075800	-.0043200	.0000800	.0009600	-.0042100	-.0014500	-.0026200
35.0	-.0051300	-.0066100	-.0095200	-.0069800	-.0006700	-.0003400	-.0055300	-.0047400	-.0031500
40.0	-.0055800	-.0048200	-.0114500	-.0096300	-.0014200	-.0016300	-.0068500	-.0080300	-.0036700
45.0	-.0061000	-.0059700	-.0096200	-.0063500	-.0029400	-.0024600	-.0076700	-.0068700	-.0022200
50.0	-.0066100	-.0071200	-.0077900	-.0030700	-.0044500	-.0032800	-.0084900	-.0057100	-.0007700
55.0	-.0095700	-.0076500	-.0098100	-.0060600	-.0084100	-.0102500	-.0139600	-.0047100	-.0037400
60.0	-.0095800	-.0101400	-.0068900	-.0140300	-.0157900	-.0077100	-.0104400	-.0041900	-.0022600
65.0	-.0085800	-.0136000	-.0103900	-.0175100	-.0113400	-.0056900	-.0144600	-.0072000	-.0027600
70.0	-.0080700	-.0081400	-.0107100	-.0126300	-.0049500	.0002300	-.0106100	-.0047200	-.0017700
75.0	-.0070850	-.0084050	-.0094900	-.0128350	-.0052250	-.0025450	-.0071250	-.0034650	-.0020150
80.0	-.0061000	-.0086700	-.0082700	-.0130400	-.0055000	-.0053200	-.0036400	-.0022100	-.0022600
85.0	-.0056200	-.0079350	-.0070550	-.0108100	-.0064850	-.0038350	-.0026200	-.0022100	-.0027450
90.0	-.0051400	-.0072000	-.0058400	-.0085800	-.0074700	-.0023500	-.0016000	-.0022100	-.0032300

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 13

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0016000	-.0016000	-.0016000	-.0016000	-.0016000	-.0016000	-.0016000	-.0016000	-.0016000
5.0	-.0015950	-.0015950	-.0015950	-.0015950	-.0015950	-.0015950	-.0015950	-.0015950	-.0015950
10.0	-.0015900	-.0015900	-.0015900	-.0015900	-.0015900	-.0015900	-.0015900	-.0015900	-.0015900
15.0	-.0017500	-.0017500	-.0017500	-.0017500	-.0017500	-.0017500	-.0017500	-.0017500	-.0017500
20.0	-.0019100	-.0019100	-.0019100	-.0019100	-.0019100	-.0019100	-.0019100	-.0019100	-.0019100
25.0	-.0009500	-.0005450	-.0008150	-.0012050	-.0016950	-.0009500	-.0016650	-.0010800	-.0011100
30.0	.0000100	.0008200	.0002800	-.0005000	-.0014800	.0000100	-.0014200	-.0002500	-.0003100
35.0	.0001500	.0003800	.0000800	-.0005600	.0003600	.0004800	-.0011000	-.0004600	-.0003200
40.0	.0002900	-.0000600	-.0001200	-.0006300	.0022000	.0009400	-.0007700	-.0006700	-.0003300
45.0	.0000200	.0001700	-.0002100	-.0002700	.0011300	.0002200	-.0006400	-.0003800	-.0008100
50.0	-.0002500	.0003900	-.0002900	.0001000	.0000600	-.0005100	-.0005000	-.0000800	-.0012900
55.0	-.0003800	-.0007400	-.0015100	-.0006300	-.0006800	.0000500	.0003800	-.0007600	-.0006300
60.0	-.0001800	-.0004200	-.0008600	-.0011400	-.0010100	-.0005400	-.0000600	-.0003100	-.0005400
65.0	-.0000600	-.0003200	-.0008100	-.0009500	-.0005200	-.0002900	.0002700	-.0001200	-.0006500
70.0	-.0003200	-.0003900	-.0002900	-.0012500	-.0008600	-.0005100	.0001300	-.0004600	-.0006900
75.0	-.0003400	-.0002400	-.0001800	-.0008050	-.0004800	-.0004350	-.0000850	-.0003200	-.0005850
80.0	-.0003600	-.0000900	-.0000700	-.0003600	-.0001000	-.0003600	-.0003000	-.0001800	-.0004800
85.0	-.0001750	-.0000300	-.0001150	-.0002850	-.0004400	-.0004300	-.0001850	-.0002200	-.0004050
90.0	.0000100	.0000300	-.0001600	-.0002100	-.0007800	-.0005000	-.0000700	-.0002600	-.0003300

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 14

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0004500	-.0004500	-.0004500	-.0004500	-.0004500	-.0004500	-.0004500	-.0004500	-.0004500
5.0	-.0003200	-.0003200	-.0003200	-.0003200	-.0003200	-.0003200	-.0003200	-.0003200	-.0003200
10.0	-.0001900	-.0001900	-.0001900	-.0001900	-.0001900	-.0001900	-.0001900	-.0001900	-.0001900
15.0	-.0000750	-.0000750	-.0000750	-.0000750	-.0000750	-.0000750	-.0000750	-.0000750	-.0000750
20.0	.0000400	.0000400	.0000400	.0000400	.0000400	.0000400	.0000400	.0000400	.0000400
25.0	.0003700	.0009050	.0009550	.0006250	.0013200	.0007050	-.0004400	.0002750	.0004100
30.0	.0007000	.0017700	.0018700	.0012100	.0012800	.0013700	-.0009200	.0005100	.0007800
35.0	.0009700	.0015000	.0018800	.0008100	.0023200	.0030400	.0005200	.0003600	.0008300
40.0	.0012300	.0012200	.0018800	.0004100	.0033600	.0047100	.0019500	.0002000	.0008700
45.0	.0014200	.0026700	.0030900	.0047400	.0040200	.0031900	-.0004600	.0000200	.0017500
50.0	.0016100	.0041200	.0043000	.0090700	.0046800	.0016700	-.0028600	-.0001600	.0026300
55.0	.0031700	.0043400	.0069000	.0086000	.0022100	-.0004200	-.0039200	.0013300	.0018600
60.0	.0025000	.0074000	.0073800	.0006600	-.0043600	-.0013200	-.0043100	.0001400	.0020500
65.0	-.0000400	.0037300	.0050800	-.0001300	-.0027500	-.0011100	.0041700	.0020500	.0036300
70.0	.0021200	-.0000200	.0046500	.0018700	.0093500	.0087000	.0014500	.0011000	.0023400
75.0	.0021400	.0015400	.0035900	.0018950	.0052300	.0052550	.0009950	-.0012900	.0014450
80.0	.0021600	.0031000	.0025300	.0019200	.0011100	.0018100	.0005400	-.0036800	.0005500
85.0	.0018950	.0022350	.0026550	.0016400	.0021400	.0013300	-.0008450	-.0017100	.0007200
90.0	.0016300	.0013700	.0027800	.0013600	.0031700	.0008500	-.0022300	.0002600	.0008900

ORIGINAL COEF ARRAY

COEFFICIENT NUMBER 15

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0039200	.0039200	.0039200	.0039200	.0039200	.0039200	.0039200	.0039200	.0039200
5.0	.0029500	.0029500	.0029500	.0029500	.0029500	.0029500	.0029500	.0029500	.0029500
10.0	.0019900	.0019900	.0019900	.0019900	.0019900	.0019900	.0019900	.0019900	.0019900
15.0	.0013100	.0013100	.0013100	.0013100	.0013100	.0013100	.0013100	.0013100	.0013100
20.0	.0006400	.0006400	.0006400	.0006400	.0006400	.0006400	.0006400	.0006400	.0006400
25.0	-.0001200	-.0003500	-.0002800	-.0002700	-.0005600	.0003000	-.0003400	-.0005500	-.0002900
30.0	-.0008700	-.0013400	-.0011900	-.0012600	-.0017500	-.0000400	-.0013200	-.0017400	-.0012100
35.0	-.0014700	-.0019300	-.0021500	-.0022600	-.0026700	-.0018100	-.0023200	-.0019600	-.0015300
40.0	-.0020600	-.0025200	-.0031100	-.0032500	-.0035900	-.0035800	-.0033100	-.0021700	-.0018400
45.0	-.0025700	-.0027400	-.0035300	-.0041000	-.0042000	-.0041000	-.0034000	-.0026600	-.0020600
50.0	-.0030800	-.0029500	-.0039500	-.0049400	-.0048100	-.0046100	-.0034800	-.0031400	-.0022700
55.0	-.0034200	-.0035300	-.0035600	-.0045900	-.0043900	-.0048000	-.0033900	-.0029800	-.0026500
60.0	-.0037600	-.0041100	-.0031600	-.0042300	-.0039600	-.0049800	-.0033000	-.0028200	-.0030300
65.0	-.0037400	-.0043500	-.0038100	-.0044100	-.0044500	-.0046500	-.0036100	-.0035800	-.0034100
70.0	-.0037100	-.0045900	-.0044600	-.0045900	-.0049300	-.0043200	-.0039100	-.0043300	-.0037800
75.0	-.0037800	-.0042900	-.0046600	-.0050600	-.0052700	-.0048600	-.0045200	-.0039000	-.0037200
80.0	-.0038600	-.0039900	-.0048700	-.0055400	-.0056100	-.0054000	-.0051400	-.0034700	-.0036600
85.0	-.0038600	-.0039900	-.0048700	-.0055400	-.0056100	-.0054000	-.0051400	-.0034700	-.0036600
90.0	-.0038600	-.0039900	-.0048700	-.0055400	-.0056100	-.0054000	-.0051400	-.0034700	-.0036600

ØRIGINAL CØEF ARRAYS

ALPHA	CØEFFICIENT NUMBER 16	CØEFFICIENT NUMBER 17	CØEFFICIENT NUMBER 18	CØEFFICIENT NUMBER 19	CØEFFICIENT NUMBER 20
.0	-.0900300	-.1499100	-.0093800	.6745500	.0442700
5.0	-.0848450	-.1552450	-.0056250	.6642550	.0833550
10.0	-.0796600	-.1605800	-.0018700	.6539600	.1224400
15.0	-.1461450	-.1878150	.0021500	.7844600	.2090700
20.0	-.2126300	-.2150500	.0061700	.9149600	.2957000
25.0	-.1868150	-.2823250	.0149950	.8538050	.4314750
30.0	-.1610000	-.3496000	.0238200	.7926500	.5672500
35.0	.4803700	-.5968400	.0135400	-.0559000	.8836100
40.0	1.0398000	-.5428000	.0024200	-1.4989000	1.2342000
45.0	.4494600	-.3158900	-.0349700	-1.1569000	.8064500
50.0	.0281500	-.1539500	-.0513000	-.9637100	.3390700
55.0	-.2988800	-.1466100	-.1392100	.8064800	.1203200
60.0	-.2090400	-.1379800	-.0500000	.0723700	.0570300
65.0	-.4677900	-.1066500	-.0855100	.4972700	.0592800
70.0	-.1274600	-.0924100	-.1500200	-.1406000	-.0296900
75.0	.1758550	-.1187200	-.2026350	.0052200	-.0020600
80.0	.4791700	-.1450300	-.2552500	.1510400	.0255700
85.0	.3845350	-.1429850	-.2556450	.0805750	.0044600
90.0	.2899000	-.1409400	-.2560400	.0101100	-.0166500

ORIGINAL COEF ARRAYS

ALPHA	COEFFICIENT NUMBER 21	COEFFICIENT NUMBER 22	COEFFICIENT NUMBER 23	COEFFICIENT NUMBER 24
.0	-.1544900	-9.5521000	-23.8120000	.0775200
5.0	-.1638950	-7.3468000	-23.5385000	.2832400
10.0	-.1733000	-5.1415000	-23.2650000	.4889700
15.0	-.2118200	-6.9284000	-25.5300000	.8523800
20.0	-.2503400	-8.7173000	-27.7950000	1.2158000
25.0	-.2733200	-18.9971000	-31.2390000	2.1057000
30.0	-.2963000	-29.2770000	-34.6830000	3.0956000
35.0	-.2485800	-43.0430000	-38.0320000	3.0868000
40.0	-.1969500	-57.4430000	-40.5800000	3.3882000
45.0	-.0453900	-66.2660000	-39.7320000	3.2705000
50.0	.2186400	-67.8550000	-29.9610000	3.6210000
55.0	.8685800	-56.7040000	-25.2800000	3.5210000
60.0	.3059700	-49.2050000	-21.5510000	2.9647000
65.0	.4058700	-39.2650000	-16.1330000	3.0295000
70.0	.2239400	-29.3060000	-13.8460000	3.3316000
75.0	.0955100	-19.8660000	-7.3528000	3.7809000
80.0	-.0329200	-10.4260000	-.8596000	4.2302000
85.0	-.1074200	-5.8258000	-8.3738000	3.1020000
90.0	-.1819200	-1.2256000	-15.8880000	1.9739000

USABLE COEF ARRAY

COEFFICIENT NUMBER 1

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	2.0274678	1.4876150	.9477622	.4079094	.0000000	-.6717962	-1.2116489	-1.7515017	-2.2913545
5.0	3.3401649	2.4862497	1.6323346	.7784194	.0000000	-.9294109	-1.7833261	-2.6372413	-3.4911564
10.0	4.6528620	3.4848845	2.3169069	1.1489294	.0000000	-1.1870257	-2.3550033	-3.5229808	-4.6909584
15.0	4.1878081	3.1141422	2.0404763	.9668104	.0000000	-1.1805215	-2.2541874	-3.3278533	-4.4015192
20.0	3.7227542	2.7433999	1.7640456	.7846914	.0000000	-1.1740172	-2.1533715	-3.1327258	-4.1120801
25.0	3.6567825	2.3635982	1.1519492	.2857224	-.1663230	-1.0076942	-1.2086291	-2.5991449	-3.7039383
30.0	3.5908108	1.9837964	.5398528	-.2132465	-.3326460	-.8413713	-.2638867	-2.0655641	-3.2957966
35.0	2.9269127	1.9963403	.7596035	-.2197507	-.7280115	-.6592522	-.5589010	-2.0404763	-3.1763972
40.0	2.4358418	1.9963403	.9668104	-.2383343	-.9728500	-.4896771	-.8664591	-2.0214281	-3.0700062
45.0	3.4086918	2.0088842	1.2618246	.2764306	-.4831729	-.4706290	-1.3185045	-2.4734735	-3.3836040
50.0	3.6284426	1.9020287	1.2934167	.5649406	-.1946629	-.5212692	-1.3059606	-2.4483857	-3.0384141
55.0	3.8607372	3.1076380	2.1910032	.9542665	.0566799	-1.0546178	-2.1784593	-2.6179608	-3.6600347
60.0	3.8481933	3.1387654	2.3415302	1.1363855	.1193995	-1.0797056	-2.3731222	-3.1954453	-3.8105616
65.0	3.8858251	3.1011337	2.5361931	1.2302325	.0315921	-1.2427764	-2.3229466	-3.1829014	-3.84215[illegible]
70.0	4.0493605	3.0825501	2.1844990	1.2869124	.0627196	-1.1865611	-2.1970429	-3.0198306	-3.9174171
75.0	4.0084766	3.0511904	2.1092355	1.2523005	-.0439037	-1.1331333	-2.1501194	-3.0511904	-3.9016211
80.0	3.9675928	3.0198306	2.0339720	1.2176886	-.1505269	-1.0797056	-2.1031958	-3.0825501	-3.8858251
85.0	3.9613208	2.9568787	2.1250315	1.2334846	.0250878	-1.1110654	-2.1533715	-2.9914906	-3.8481933
90.0	3.9550489	2.8939269	2.2160910	1.2492807	.2007026	-1.1424251	-2.2035471	-2.9004311	-3.8105616

USABLE COEF ARRAY

COEFFICIENT NUMBER 2

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.0676324	.0676324	.0676324	.0676324	.0676324	.0676324	.0676324	.0676324	.0676324
5.0	-.0937283	-.0937283	-.0937283	-.0937283	-.0937283	-.0937283	-.0937283	-.0937283	-.0937283
10.0	-.2550891	-.2550891	-.2550891	-.2550891	-.2550891	-.2550891	-.2550891	-.2550891	-.2550891
15.0	-.3181895	-.3181895	-.3181895	-.3181895	-.3181895	-.3181895	-.3181895	-.3181895	-.3181895
20.0	-.3812900	-.3812900	-.3812900	-.3812900	-.3812900	-.3812900	-.3812900	-.3812900	-.3812900
25.0	-.2356704	-.2825640	-.4655653	-.4335230	-.6002409	-.5275990	-.4900464	-.4235455	-.0429038
30.0	-.0900509	-.1838381	-.5498407	-.4857560	-.8191917	-.6739081	-.5988029	-.4658010	.2954823
35.0	.1408990	-.2097219	-.5441948	-.5936049	-.8968311	-.7247326	-.6206437	-.4189015	.0772976
40.0	.3841424	-.2355938	-.5262671	-.6974345	-.9062134	-.7715379	-.6302028	-.3554770	-.1368561
45.0	-.0192124	-.0238800	-.3829401	-.7427428	-.9786195	-.8080179	-.3867826	-.5452438	-.3961177
50.0	-.2091561	.0431985	-.4071383	-.7896423	-1.0366929	-.8140291	-.4313366	-.6424139	-.2512820
55.0	-.3719902	-.3069744	-.8940613	-.9581223	-1.1070598	-.9901941	-.5057346	-.6517962	-.5752647
60.0	-.8035743	-.4899757	-.4608742	-1.1884592	-1.2472752	-1.0754595	-.7096456	-.8344202	-.6447712
65.0	-.9060838	-.7774666	-.6106839	-1.3258929	-1.3204709	-1.1004121	-1.1936454	-1.0723950	-.7386646
70.0	-.8234468	-1.3022015	-1.4368063	-1.2624801	-1.4575510	-1.4261982	-1.6567473	-1.1466751	-.8650069
75.0	-.9854381	-1.4137632	-1.6516200	-1.6434872	-1.7819227	-1.7174491	-1.7492733	-1.2688744	-.9969361
80.0	-1.1474295	-1.5253249	-1.8664338	-2.0244942	-2.1062944	-2.0087000	-1.8417994	-1.3910736	-1.1288653
85.0	-1.2926483	-1.6741327	-1.9686250	-2.1879177	-2.3910036	-2.1818475	-1.9708055	-1.5585046	-1.2017429
90.0	-1.4378671	-1.8229406	-2.0708162	-2.3513411	-2.6757128	-2.3549950	-2.0998116	-1.7259356	-1.2746204

USABLE COEF ARRAY

COEFFICIENT NUMBER 3

BETA ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.2216668	-.1665457	-.1114246	-.0563035	.0000000	.0539388	.1090599	.1641810	.2193022
5.0	-.1917620	-.1446522	-.0975016	-.0503510	.0000000	.0439501	.0911007	.1382513	.1854018
10.0	-.1619387	-.1227587	-.0835786	-.0443986	.0000000	.0339615	.0731415	.1123215	.1515015
15.0	-.0930984	-.0718776	-.0506160	-.0293544	.0000000	.0131687	.0344303	.0556919	.0769535
20.0	-.0243397	-.0209966	-.0176534	-.0143103	.0000000	-.0076240	-.0042809	-.0009377	.0024054
25.0	.0897553	.0558958	.0816217	.0353476	-.0119049	-.0937711	-.0924869	-.1063487	-.0888380
30.0	.2038503	.1327881	.1808968	.0850056	-.0238097	-.1799183	-.1806929	-.2117597	-.1800814
35.0	.2146544	.1629987	.1552116	.1478730	-.0291506	-.2408695	-.1928016	-.2337755	-.2497574
40.0	.2237053	.1920678	.1283849	.2095581	-.0656806	-.3047154	-.2060927	-.2575445	-.3194334
45.0	.2465366	.1396375	.0279275	.1101199	-.1011097	-.2754833	-.0354700	-.2627630	-.3449147
50.0	.2200768	.0691053	-.0400362	-.1095899	-.1365389	-.0819886	.0037101	-.2524074	-.3480948
55.0	.1571686	-.0076240	-.1509715	-.1036783	.0321676	.0896126	.0621743	-.2023010	-.2672477
60.0	.1700519	-.1036783	-.2049103	.0720407	.3526203	.1428583	.0557734	-.1256126	-.2071934
65.0	.1205571	-.1177032	-.2550575	-.0310668	.3388807	.2402172	-.1011505	-.1150531	-.1653634
70.0	-.0279275	-.0264598	.0551211	-.2130643	-.1701742	-.0895718	-.3233066	-.0143103	-.1064506
75.0	-.0612774	-.1096103	.0541223	-.1162151	-.0641721	-.0481494	-.1848311	.0785435	-.0371823
80.0	-.0946273	-.1927608	.0531234	-.0193658	.0418301	-.0067271	-.0463556	.1713973	.0320860
85.0	-.0914676	-.0861471	.0132095	-.0123533	.0109264	.0044236	.0153092	.1024348	.0571800
90.0	-.0883080	.0204666	-.0267044	-.0053409	-.0199773	.0155742	.0769739	.0334722	.0822740

USABLE COEF ARRAY

COEFFICIENT NUMBER 4

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	3.3176437	2.4882328	1.6588219	.8294109	.0000000	-.8294109	-1.6588219	-2.4882328	-3.3176437
5.0	3.4250940	2.5803375	1.7340183	.8908245	.0000000	-.7986885	-1.6434450	-2.4882015	-3.2485730
10.0	3.5325442	2.6724421	1.8123401	.9522380	.0000000	-.7679661	-1.6280682	-2.4881703	-3.3482723
15.0	3.4097171	2.5956830	1.7800862	.9676148	.0000000	-.6604534	-1.4744875	-2.2885216	-3.1025557
20.0	3.2868901	2.5189239	1.7509578	.9829917	.0000000	-.5529406	-1.3209068	-2.0888729	-2.8568390
25.0	3.3022356	2.4728247	1.7048586	.8447565	.1689576	-.3532607	-1.1058812	-1.9659833	-2.7032270
30.0	3.3175812	2.4267255	1.6587593	.7065213	.3379151	-.1535807	-.8908557	-1.8430937	-2.5496151
35.0	3.5018531	2.5803062	1.9045385	1.0751276	.3071615	-.3686062	-1.1980172	-2.0581192	-2.6725046
40.0	3.7168786	2.7339494	2.1502552	1.4437338	.3071615	-.5529406	-1.5051786	-2.2424536	-2.7953317
45.0	3.5632979	3.3482723	2.4881703	1.5973771	.2457167	-.7986573	-1.8124026	-2.7339494	-2.9489750
50.0	3.5940515	3.5326067	2.8567765	1.7509578	.1843344	-1.1980172	-2.0888104	-2.9796661	-3.1640005
55.0	3.7476322	3.4097171	2.7339494	1.7509578	.3071615	-1.1058812	-1.9966744	-2.9489750	-3.0718020
60.0	3.6861874	3.4404083	2.4574791	1.8124026	.7065213	-.9215469	-1.9045385	-2.8875302	-3.1332468
65.0	3.6861874	3.5632979	2.4267255	1.8430937	.5529406	-.8294109	-2.0274281	-2.9489750	-3.1640005
70.0	3.7476322	3.4711619	3.1332468	1.4130427	.1535807	-1.1058812	-2.5803062	-2.9796661	-3.1640005
75.0	3.7015643	3.4097171	3.0257341	1.5973458	.0614448	-1.2440851	-2.6110286	-2.9643205	-3.1486236
80.0	3.6554963	3.3482723	2.9182213	1.7816489	-.0306911	-1.3822890	-2.6417510	-2.9489750	-3.1332468
85.0	3.5786747	3.2868275	2.7799862	1.7202041	.0153768	-1.4130114	-2.5649606	-2.9489750	-3.0871789
90.0	3.5018531	3.2253828	2.6417510	1.6587593	.0614448	-1.4437338	-2.4881703	-2.9489750	-3.0411109

USABLE COEF ARRAY

COEFFICIENT NUMBER 5

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.3422281	-.3422281	-.3422281	-.3422281	-.3422281	-.3422281	-.3422281	-.3422281	-.3422281
5.0	-.2462167	-.2462167	-.2462167	-.2462167	-.2462167	-.2462167	-.2462167	-.2462167	-.2462167
10.0	-.1502678	-.1502678	-.1502678	-.1502678	-.1502678	-.1502678	-.1502678	-.1502678	-.1502678
15.0	-.1627693	-.1627693	-.1627693	-.1627693	-.1627693	-.1627693	-.1627693	-.1627693	-.1627693
20.0	-.1752708	-.1752708	-.1752708	-.1752708	-.1752708	-.1752708	-.1752708	-.1752708	-.1752708
25.0	-.1293278	-.1668948	-.1878348	-.2003363	-.1502678	-.1668948	-.2211512	-.1867722	-.1377038
30.0	-.0834474	-.1585813	-.2003363	-.2253392	-.1252024	-.1585813	-.2670942	-.2170258	-.1001369
35.0	.0500684	-.1085129	-.1335784	-.1502678	-.1085129	-.1502678	-.2003363	-.1252024	-.0250655
40.0	.1752708	.0166895	-.0834474	-.0918234	-.0834474	-.1502678	-.1418918	-.0500684	.0333790
45.0	.1418918	.1418918	-.0083760	-.0751339	-.1168889	-.1252024	.0000000	-.0083760	.0333790
50.0	.1669573	.2086498	.0500684	-.1252024	-.1252024	-.0834474	.0918234	.0918234	.1585813
55.0	.2337152	.1752708	.0667579	-.0667579	-.0751339	.0000000	.1752708	.1669573	.1752708
60.0	.1752708	.1836468	.2003363	.0751339	.1252024	.1252024	.2670942	.2420912	.2337152
65.0	.2420912	.2754702	.3088492	.2086498	.2420912	.2754702	.2587807	.2670942	.2921597
70.0	.2754702	.2587807	.2921597	.2253392	.2170258	.2420912	.2337152	.3088492	.3004732
75.0	.3088492	.2734074	.2879717	.2253392	.2379032	.2379032	.2629062	.4037354	.3589176
80.0	.3422281	.3506041	.2837837	.2253392	.2587807	.2337152	.2921597	.4674305	.4173620
85.0	.3589176	.3547921	.3380401	.2814709	.2967852	.3046612	.3839831	.4507410	.4466155
90.0	.3756071	.3589176	.3922966	.3338521	.3422281	.3756071	.4758065	.4340515	.4758065

USABLE CBEF ARRAY

COEFFICIENT NUMBER 6

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.3624805	-.3624805	-.3624805	-.3624805	-.3624805	-.3624805	-.3624805	-.3624805	-.3624805
5.0	-2.7184476	-2.7184476	-2.7184476	-2.7184476	-2.7184476	-2.7184476	-2.7184476	-2.7184476	-2.7184476
10.0	-5.0744772	-5.0744772	-5.0744772	-5.0744772	-5.0744772	-5.0744772	-5.0744772	-5.0744772	-5.0744772
15.0	-7.6481576	-7.6481576	-7.6481576	-7.6481576	-7.6481576	-7.6481576	-7.6481576	-7.6481576	-7.6481576
20.0	-10.2218380	-10.2218380	-10.2218380	-10.2218380	-10.2218380	-10.2218380	-10.2218380	-10.2218380	-10.2218380
25.0	-9.2792262	-10.2580923	-10.8375361	-11.7076394	-13.0127942	-12.2151996	-10.9462990	-10.4393638	-9.6055149
30.0	-8.3366143	-10.2937216	-11.4538592	-13.1934407	-15.8037504	-14.2085611	-11.6713850	-10.7287732	-8.9891918
35.0	-9.4967520	-10.9462990	-12.3964711	-14.3535783	-17.7608577	-15.1511730	-12.3239625	-10.7287732	-9.1342090
40.0	-10.5837560	-11.5988764	-13.2659493	-15.5137160	-18.2684179	-16.0931598	-12.9040313	-11.1638248	-9.2792262
45.0	-10.5837560	-12.3964711	-13.9910353	-15.8762590	-18.1959093	-16.2656684	-13.9185267	-11.2363334	-9.7142778
50.0	-10.7287732	-12.9765399	-13.9910353	-15.2961902	-17.2532975	-15.3686988	-13.9910353	-11.3813506	-9.8592950
55.0	-11.3088420	-12.6865055	-13.5559837	-14.9336472	-16.3831942	-14.8611386	-13.1215571	-11.8889109	-10.3662302
60.0	-11.3088420	-13.2659493	-14.4985956	-15.0786644	-16.0212763	-15.0786644	-13.9910353	-12.3239625	-10.7287732
65.0	-11.9614195	-13.7010009	-14.7161214	-15.2236816	-16.2381770	-15.3686988	-13.9910353	-12.3239625	-11.163824[illegible]
70.0	-12.7590141	-13.8460181	-14.4260869	-15.6587332	-16.2381770	-15.0061558	-13.7010009	-12.9765399	-11.6713850
75.0	-13.0121692	-14.0997982	-14.8248843	-15.5862246	-16.0931598	-15.3324445	-14.3898326	-13.4472208	-11.9976738
80.0	-13.2659493	-14.3535783	-15.2236816	-15.5137160	-15.9487676	-15.6587332	-15.0786644	-13.9185267	-12.3239625
85.0	-13.2659493	-14.1723068	-14.9699015	-15.5499703	-16.0931598	-15.5499703	-15.0424101	-13.9185267	-12.4327254
90.0	-13.2659493	-13.9910353	-14.7161214	-15.5862246	-16.2381770	-15.4412074	-15.0061558	-13.9185267	-12.5414883

USABLE COEF ARRAY

COEFFICIENT NUMBER 7

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-2.6780147	-2.6780147	-2.6780147	-2.6780147	-2.6780147	-2.6780147	-2.6780147	-2.6780147	-2.6780147
5.0	-2.7524423	-2.7524423	-2.7524423	-2.7524423	-2.7524423	-2.7524423	-2.7524423	-2.7524423	-2.7524423
10.0	-2.8282481	-2.8282481	-2.8282481	-2.8282481	-2.8282481	-2.8282481	-2.8282481	-2.8282481	-2.8282481
15.0	-2.8172218	-2.8172218	-2.8172218	-2.8172218	-2.8172218	-2.8172218	-2.8172218	-2.8172218	-2.8172218
20.0	-2.8061955	-2.8061955	-2.8061955	-2.8061955	-2.8061955	-2.8061955	-2.8061955	-2.8061955	-2.8061955
25.0	-1.7669659	-2.2769327	-2.3058768	-2.7758732	-3.6869219	-3.2954880	-2.1804525	-2.1969920	-2.5746430
30.0	-.7277364	-1.7462916	-1.8055580	-2.7469291	-4.5662700	-3.7847804	-1.5560878	-1.5864101	-2.3430906
35.0	-.5843944	-.9206968	-1.5836536	-2.4795411	-4.1348657	-3.2775702	-1.3410748	-1.4141241	-1.5671141
40.0	-.4396741	-.0937236	-1.3617491	-2.2121531	-3.7034614	-2.7703600	-1.1246835	-1.2404597	-.7911376
45.0	-.3156281	-.4865359	-.9882329	-1.6442983	-3.0225868	-1.9640612	-1.1949762	-.8324863	-.5816378
50.0	-.1915821	-.8793481	-.6147167	-1.0764434	-2.3403340	-1.1563841	-1.2652689	-.4231346	-.3721379
55.0	-.0647796	-.9579106	-1.0571473	-1.1205486	-2.1487519	-1.2004893	-1.1439795	-.7401410	-.4851576
60.0	.0634013	-1.0364730	-1.4995780	-1.1632755	-1.9571698	-1.2445946	-1.0213118	-1.0557690	-.5981772
65.0	-.3693813	-.8269731	-.8504040	-.9951243	-1.7518048	-.9606671	-.9427494	-.6836311	-.5485588
70.0	-.8021639	-.6174733	-.1998518	-.8255948	-1.5464398	-.6753614	-.8641869	-.3101149	-.4989405
75.0	-.8779698	-.7346278	-.4355392	-.5416674	-1.3052393	-.6284996	-.8903744	-.6257430	-.7360061
80.0	-.9551540	-.8517823	-.6712265	-.2591182	-1.0640388	-.5816378	-.9179402	-.9413711	-.9744500
85.0	-.9551540	-.8517823	-.6712265	-.2591182	-1.0640388	-.5816378	-.9179402	-.9441277	-.9744500
90.0	-.9551540	-.8517823	-.6712265	-.2591182	-1.0640388	-.5816378	-.9179402	-.9482625	-.9744500

USABLE COEF ARRAY

COEFFICIENT NUMBER 8

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.9093835	-.9093835	-.9093835	-.9093835	-.9093835	-.9093835	-.9093835	-.9093835	-.9093835
5.0	-.9109428	-.9109428	-.9109428	-.9109428	-.9109428	-.9109428	-.9109428	-.9109428	-.9109428
10.0	-.9125022	-.9125022	-.9125022	-.9125022	-.9125022	-.9125022	-.9125022	-.9125022	-.9125022
15.0	-.9452494	-.9452494	-.9452494	-.9452494	-.9452494	-.9452494	-.9452494	-.9452494	-.9452494
20.0	-.9779966	-.9779966	-.9779966	-.9779966	-.9779966	-.9779966	-.9779966	-.9779966	-.9779966
25.0	-.6658589	-.6097209	-.7079624	-.8298546	-1.0168513	-.9131520	-.7343421	-.7582527	-.4159669
30.0	-.3537213	-.2414453	-.4379283	-.6817127	-1.0557061	-.8483074	-.4906876	-.5385089	.1460627
35.0	-.2224728	-.3927060	-.3381274	-.5408479	-.9226383	-.6897696	-.4220745	-.2653560	.2136362
40.0	-.0909643	-.5439667	-.2380667	-.3999832	-.7893105	-.5312317	-.3532015	.0077969	.2809498
45.0	-.0327472	-.1834881	-.2339083	-.2913458	-.5891890	-.3906268	-.2536605	-.0223512	.2170149
50.0	.0257299	.1772505	-.2294900	-.1824485	-.3890675	-.2500220	-.1538597	-.0522395	.1530800
55.0	-.2305296	.2367672	.1546394	-.1242313	-.2032403	-.0959024	-.0829075	-.0714720	-.0382050
60.0	-.4867891	.2962838	.5387688	-.0660141	-.0171533	.0582172	-.0116954	-.0907044	-.2292301
65.0	-.3609985	-.0800486	.1224120	.0597766	.0488608	.1803693	.0002599	-.1840079	-.2609377
70.0	-.2352078	-.4561212	-.2939448	.1853073	.1148750	.3022615	.0122152	-.2773113	-.2923854
75.0	-.2298799	-.3070696	-.2970635	-.0145543	-.0296284	.0319675	-.1196831	-.2190941	-.3152564
80.0	-.2245520	-.1580180	-.3001823	-.2144159	-.1741317	-.2383266	-.2515814	-.1608769	-.3381274
85.0	-.2245520	-.1580180	-.3001823	-.2144159	-.1741317	-.2383266	-.2515814	-.1608769	-.3381274
90.0	-.2245520	-.1580180	-.3001823	-.2144159	-.1741317	-.2383266	-.2515814	-.1608769	-.3381274

USABLE COEF ARRAY

COEFFICIENT NUMBER 9

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.6670917	.6670917	.6670917	.6670917	.6670917	.6670917	.6670917	.6670917	.6670917
5.0	.6395259	.6436608	.6436608	.6436608	.6436608	.6436608	.6436608	.6436608	.6436608
10.0	.6202299	.6202299	.6202299	.6202299	.6202299	.6202299	.6202299	.6202299	.6202299
15.0	.6188516	.6188516	.6188516	.6188516	.6188516	.6188516	.6188516	.6188516	.6188516
20.0	.6174733	.6174733	.6174733	.6174733	.6174733	.6174733	.6174733	.6174733	.6174733
25.0	.4121083	.3838534	.4121083	.4996296	.6629568	.3673139	.3611116	.3101149	.3493962
30.0	.2067433	.1502335	.2067433	.3817859	.7084403	.1171545	.1047499	.0027566	.0813190
35.0	.2039867	.0799407	.1350723	.2963320	.5940424	.1888255	.0854539	-.1447203	.1405854
40.0	.2012301	.0082697	.0620230	.2094999	.4782661	.2604965	.0661579	-.2908189	.1998518
45.0	.1102631	.0716710	.0578881	.0813190	.1695295	.1047499	.0592664	-.1364506	.1447203
50.0	.0192960	.1350723	.0523750	-.0468618	-.1405854	-.0523750	.0523750	.0179178	.0895888
55.0	.0868322	.0909670	.0771842	-.0702927	-.0964802	-.1681512	-.0413487	.0868322	.0647796
60.0	-.0275658	.0909670	-.1722861	-.0937236	.1970953	-.0799407	.0261875	-.0055132	.111641.
65.0	.0413487	.2039867	-.0565098	.2274176	.3597333	.1033716	.2122564	-.0289441	.0441052
70.0	.2012301	.1819341	.2784143	.2563617	.1819341	.2219045	-.0110263	.0634013	.0661579
75.0	.2136347	.2170804	.3032235	.3232087	.1715969	.1895147	.0358355	.1095739	.1006151
80.0	.2260393	.2522268	.3280327	.3900557	.1612598	.1571249	.0826973	.1557466	.1350723
85.0	.1695295	.2074324	.2377548	.2983995	.1950278	.0537533	.0468618	.0523750	-.0034457
90.0	.1130197	.1626381	.1474769	.2067433	.2287959	-.0496184	.0110263	-.0509967	-.1419637

USABLE COEF ARRAY

COEFFICIENT NUMBER 10

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.1741513	.1741513	.1741513	.1741513	.1741513	.1741513	.1741513	.1741513	.1741513
5.0	.1434187	.1434187	.1434187	.1434187	.1434187	.1434187	.1434187	.1434187	.1434187
10.0	.1126861	.1126861	.1126861	.1126861	.1126861	.1126861	.1126861	.1126861	.1126861
15.0	.1075640	.1075640	.1075640	.1075640	.1075640	.1075640	.1075640	.1075640	.1075640
20.0	.1024419	.1024419	.1024419	.1024419	.1024419	.1024419	.1024419	.1024419	.1024419
25.0	.0717094	.0358547	.1434187	.1382966	.1690292	-.3073258	.0358547	-.1024419	.1126861
30.0	.0409768	-.0307326	.1843955	.1741513	.2356165	-.7170936	-.0307326	-.3073258	.1229303
35.0	-.1331745	.0000000	.1331745	.2356165	-.0614652	-.2868374	.0614652	-.1126861	.1126861
40.0	-.2970816	.0307326	.0717094	.2970816	-.3585468	.1434187	.1536629	.0819536	.1024419
45.0	-.1229303	-.2151281	.0614652	.1126861	-.3175700	.0819536	.0819536	.0819536	-.0102442
50.0	.0614652	-.4507446	.0512210	-.0717094	-.2663491	.0204884	.0000000	.0081954	-.1229303
55.0	.0307326	.0204884	.1126861	-.0102442	-.0204884	.0717094	.0102442	.0921978	.0204884
60.0	-.0819536	-.1126861	.0717094	.0102442	.0409768	.0717094	.0102442	.0614652	.0717094
65.0	-.1024419	.0717094	.1024419	.0819536	.0921978	-.0512210	-.0512210	.0307326	.0409768
70.0	.0409768	.0512210	.0614652	.0819536	.0204884	-.0307326	.0512210	.0307326	.0512210
75.0	.0409768	.0204884	.0563431	.1280524	-.0358547	.0153663	.0512210	.0204884	.0460989
80.0	.0409768	-.0102442	.0512210	.1741513	-.0921978	.0614652	.0512210	.0102442	.0409768
85.0	.0102442	.0051221	.0665873	.1434187	.0307326	.0256105	.0102442	.0051221	.0358547
90.0	-.0204884	.0204884	.0819536	.1126861	.1536629	-.0102442	-.0307326	.0000000	.0307326

USABLE CBEF ARRAY

COEFFICIENT NUMBER 11

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.1213623	-.1213623	-.1213623	-.1213623	-.1213623	-.1213623	-.1213623	-.1213623	-.1213623
5.0	-.1182158	-.1182158	-.1182158	-.1182158	-.1182158	-.1182158	-.1182158	-.1182158	-.1182158
10.0	-.1150694	-.1150694	-.1150694	-.1150694	-.1150694	-.1150694	-.1150694	-.1150694	-.1150694
15.0	-.1141704	-.1141704	-.1141704	-.1141704	-.1141704	-.1141704	-.1141704	-.1141704	-.1141704
20.0	-.1132715	-.1132715	-.1132715	-.1132715	-.1132715	-.1132715	-.1132715	-.1132715	-.1132715
25.0	-.0723679	-.0759638	-.0557367	-.1006857	-.1164179	-.1033827	-.0714689	-.0611306	-.0323633
30.0	-.0314643	-.0386561	.0017980	-.0881000	-.1195643	-.0934939	-.0296663	-.0089898	.0485449
35.0	-.0341612	-.0107878	-.0152827	-.0080908	-.1222613	-.0872010	-.0449490	.0179796	.0359592
40.0	-.0359592	.0179796	-.0314643	.0728174	-.1240592	-.0800092	-.0602316	.0449490	.0233735
45.0	-.0323633	.0107878	-.0116867	-.0485449	-.1519276	-.0755143	-.0062929	.0395551	.0269694
50.0	-.0278684	.0026969	.0080908	-.1690082	-.1788970	-.0710194	.0476459	.0341612	.0296663
55.0	-.0197776	-.0665245	-.1096755	-.2157552	-.1096755	-.0332623	.0071918	.0134847	.0368582
60.0	.0476459	-.1411398	-.2436235	-.1366449	.1330490	-.0215755	.0521408	.0494439	.0044949
65.0	.0584337	-.1015847	-.2310378	-.1393419	.2193511	.1726041	.1618164	.0000000	-.0179796
70.0	-.0629286	.0044949	.1582205	.0017980	.0026969	.1869878	.0934939	-.0350602	-.0386561
75.0	-.0525903	.0202270	.0660750	-.0067423	.0112372	.0889990	.0427015	.0458480	-.0193281
80.0	-.0422521	-.0449490	-.0260704	-.0152827	.0197776	-.0089898	-.0080908	.1267562	.0000000
85.0	-.0323633	-.0422521	-.0350602	-.0116867	-.0044949	-.0004495	.0215755	.0710194	.0026969
90.0	-.0224745	-.0395551	-.0440500	-.0080908	-.0287674	.0080908	.0512419	.0152827	.0053939

USABLE COEF ARRAY

COEFFICIENT NUMBER 12

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.1184203	.1184203	.1184203	.1184203	.1184203	.1184203	.1184203	.1184203	.1184203
5.0	.1192098	.1192098	.1192098	.1192098	.1192098	.1192098	.1192098	.1192098	.1192098
10.0	.1199992	.1199992	.1199992	.1199992	.1199992	.1199992	.1199992	.1199992	.1199992
15.0	.0817100	.0817100	.0817100	.0817100	.0817100	.0817100	.0817100	.0817100	.0817100
20.0	.0434208	.0434208	.0434208	.0434208	.0434208	.0434208	.0434208	.0434208	.0434208
25.0	-.1630253	-.3094717	-.2774982	-.1488148	.0248683	.0596049	-.1444728	-.0355261	-.0817100
30.0	-.3694713	-.6623642	-.5984173	-.3410505	.0063157	.0757890	-.3323663	-.1144730	-.2068408
35.0	-.4049974	-.5218388	-.7515742	-.5510491	-.0528944	-.0268419	-.4365762	-.3742082	-.2486826
40.0	-.4405235	-.3805239	-.9039416	-.7602583	-.1121046	-.1286834	-.5407861	-.6339434	-.2897350
45.0	-.4815759	-.4713128	-.7594689	-.5013126	-.2321038	-.1942093	-.6055225	-.5423650	-.1752620
50.0	-.5218388	-.5621017	-.6149961	-.2423669	-.3513136	-.2589457	-.6702589	-.4507866	-.0607891
55.0	-.7555215	-.6039435	-.7744688	-.4784180	-.6639432	-.8092054	-1.1020983	-.3718398	-.2952613
60.0	-.7563110	-.8005212	-.5439439	-1.1076246	-1.2465711	-.6086804	-.8242053	-.3307874	-.1784199
65.0	-.6773641	-1.0736774	-.8202580	-1.3823597	-.8952575	-.4492077	-1.1415717	-.5684175	-.2178934
70.0	-.6371012	-.6426275	-.8455210	-.9970990	-.3907870	.0181578	-.8376263	-.3726292	-.1397360
75.0	-.5593386	-.6635484	-.7492058	-1.0132831	-.4124974	-.2009198	-.5624964	-.2735509	-.1590779
80.0	-.4815759	-.6844694	-.6528906	-1.0294672	-.4342078	-.4199973	-.2873666	-.1744726	-.1784199
85.0	-.4436814	-.6264434	-.5569702	-.8534157	-.5119704	-.3027612	-.2068408	-.1744726	-.2167092
90.0	-.4057869	-.5684175	-.4610497	-.6773641	-.5897331	-.1855251	-.1263150	-.1744726	-.2549984

USABLE COEF ARRAY

COEFFICIENT NUMBER 13

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.9388421	-.9388421	-.9388421	-.9388421	-.9388421	-.9388421	-.9388421	-.9388421	-.9388421
5.0	-.9359082	-.9359082	-.9359082	-.9359082	-.9359082	-.9359082	-.9359082	-.9359082	-.9359082
10.0	-.9329743	-.9329743	-.9329743	-.9329743	-.9329743	-.9329743	-.9329743	-.9329743	-.9329743
15.0	-1.0268585	-1.0268585	-1.0268585	-1.0268585	-1.0268585	-1.0268585	-1.0268585	-1.0268585	-1.0268585
20.0	-1.1207428	-1.1207428	-1.1207428	-1.1207428	-1.1207428	-1.1207428	-1.1207428	-1.1207428	-1.1207428
25.0	-.5574375	-.3197931	-.4782227	-.7070655	-.9945858	-.5574375	-.9769826	-.6337184	-.6513217
30.0	.0058678	.4811566	.1642974	-.2933882	-.8684289	.0058678	-.8332224	-.1466941	-.1819007
35.0	.0880164	.2229750	.0469421	-.3285947	.2112395	.2816526	-.6454539	-.2699171	-.1877684
40.0	.1701651	-.0352066	-.0704132	-.3696691	1.2909079	.5515697	-.4518178	-.3931401	-.1936362
45.0	.0117355	.0997520	-.1232230	-.1584296	.6630572	.1290908	-.3755368	-.2229750	-.4752888
50.0	-.1466941	.2288428	-.1701651	.0586776	.0352066	-.2992559	-.2933882	-.0469421	-.7569414
55.0	-.2229750	-.4342145	-.8860322	-.3696691	-.3990079	.0293388	.2229750	-.4459500	-.3696691
60.0	-.1056197	-.2464460	-.5046276	-.6689250	-.5926441	-.3168592	-.0352066	-.1819007	-.3168592
65.0	-.0352066	-.1877684	-.4752888	-.5574375	-.3051237	-.1701651	.1584296	-.0704132	-.3814046
70.0	-.1877684	-.2288428	-.1701651	-.7334704	-.5046276	-.2992559	.0762809	-.2699171	-.4048757
75.0	-.1995039	-.1408263	-.1056197	-.4723549	-.2816526	-.2552477	-.0498760	-.1877684	-.3432641
80.0	-.2112395	-.0528099	-.0410743	-.2112395	-.0586776	-.2112395	-.1760329	-.1056197	-.2816526
85.0	-.1026859	-.0176033	-.0674793	-.1672312	-.2581816	-.2523138	-.1085536	-.1290908	-.2376444
90.0	.0058678	.0176033	-.0938842	-.1232230	-.4576855	-.2933882	-.0410743	-.1525618	-.1936362

USABLE CØEF ARRAY

COEFFICIENT NUMBER 14

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	-.0231717	-.0231717	-.0231717	-.0231717	-.0231717	-.0231717	-.0231717	-.0231717	-.0231717
5.0	-.0164776	-.0164776	-.0164776	-.0164776	-.0164776	-.0164776	-.0164776	-.0164776	-.0164776
10.0	-.0097836	-.0097836	-.0097836	-.0097836	-.0097836	-.0097836	-.0097836	-.0097836	-.0097836
15.0	-.0038619	-.0038619	-.0038619	-.0038619	-.0038619	-.0038619	-.0038619	-.0038619	-.0038619
20.0	.0020597	.0020597	.0020597	.0020597	.0020597	.0020597	.0020597	.0020597	.0020597
25.0	.0190523	.0466008	.0491754	.0321829	.0679702	.0363023	-.0226567	.0141605	.0211120
30.0	.0360448	.0911419	.0962911	.0623060	.0659105	.0705448	-.0473732	.0262612	.0401642
35.0	.0499478	.0772389	.0968061	.0417090	.1194628	.1565375	.0267761	.0185373	.0427388
40.0	.0633359	.0628210	.0968061	.0211120	.1730151	.2425301	.1004105	.0102985	.0447985
45.0	.0731195	.1374852	.1591121	.2440749	.2070002	.1642613	-.0236866	.0010299	.0901120
50.0	.0829031	.2121495	.2214181	.4670378	.2409853	.0859926	-.1472688	-.0082388	.1354255
55.0	.1632315	.2234778	.3552988	.4428362	.1137986	-.0216269	-.2018509	.0684851	.0957762
60.0	.1287315	.3810451	.3800153	.0339851	-.2245077	-.0679702	-.2219330	.0072090	.1055595
65.0	-.0020597	.1920673	.2615823	-.0066940	-.1416046	-.0571568	.2147241	.1055598	.1869181
70.0	.1091643	-.0010299	.2394405	.0962911	.4814557	.4479855	.0746642	.0566418	.1204927
75.0	.1101941	.0792986	.1848584	.0975785	.2693062	.2705935	.0512351	-.0664254	.0744068
80.0	.1112240	.1596270	.1302762	.0988658	.0571568	.0932016	.0278060	-.1894927	.0283209
85.0	.0975785	.1150859	.1367128	.0844478	.1101941	.0684851	-.0435112	-.0880523	.0370747
90.0	.0839329	.0705448	.1431494	.0700299	.1632315	.0437687	-.1148285	.0133881	.0458284

USABLE COEF ARRAY

COEFFICIENT NUMBER 15

BETA / ALPHA	-40.0	-30.0	-20.0	-10.0	.0	10.0	20.0	30.0	40.0
.0	.5402891	.5402891	.5402891	.5402891	.5402891	.5402891	.5402891	.5402891	.5402891
5.0	.4065951	.4065951	.4065951	.4065951	.4065951	.4065951	.4065951	.4065951	.4065951
10.0	.2742794	.2742794	.2742794	.2742794	.2742794	.2742794	.2742794	.2742794	.2742794
15.0	.1805558	.1805558	.1805558	.1805558	.1805558	.1805558	.1805558	.1805558	.1805558
20.0	.0882105	.0882105	.0882105	.0882105	.0882105	.0882105	.0882105	.0882105	.0882105
25.0	-.0165395	-.0482401	-.0385921	-.0372138	-.0771842	.0413487	-.0468618	-.0758059	-.0399704
30.0	-.1199111	-.1846907	-.1640163	-.1736644	-.2412005	-.0055132	-.1819341	-.2398222	-.1667729
35.0	-.2026084	-.2660097	-.2963320	-.3114932	-.3680030	-.2494702	-.3197629	-.2701446	-.2108782
40.0	-.2839274	-.3473287	-.4286477	-.4479438	-.4948056	-.4934273	-.4562135	-.2990886	-.2536051
45.0	-.3542202	-.3776511	-.4865359	-.5650983	-.5788812	-.5650983	-.4686181	-.3666248	-.2839274
50.0	-.4245129	-.4065951	-.5444240	-.6808745	-.6629568	-.6353910	-.4796444	-.4327826	-.3128715
55.0	-.4713747	-.4865359	-.4906707	-.6326345	-.6050687	-.6615785	-.4672398	-.4107300	-.3652465
60.0	-.5182365	-.5664766	-.4355392	-.5830161	-.5458023	-.6863877	-.4548352	-.3886774	-.4176214
65.0	-.5154799	-.5995555	-.5251279	-.6078253	-.6133384	-.6409042	-.4975622	-.4934273	-.4699964
70.0	-.5113451	-.6326345	-.6147167	-.6326345	-.6794963	-.5954207	-.5389108	-.5967989	-.5209931
75.0	-.5209931	-.5912858	-.6422825	-.6974140	-.7263581	-.6698482	-.6229864	-.5375325	-.5127233
80.0	-.5320194	-.5499371	-.6712265	-.7635719	-.7732199	-.7442758	-.7084403	-.4782661	-.5044536
85.0	-.5320194	-.5499371	-.6712265	-.7635719	-.7732199	-.7442758	-.7084403	-.4782661	-.5044536
90.0	-.5320194	-.5499371	-.6712265	-.7635719	-.7732199	-.7442758	-.7084403	-.4782661	-.5044536

USABLE COEF ARRAYS

ALPHA	COEFFICIENT NUMBER 16	COEFFICIENT NUMBER 17	COEFFICIENT NUMBER 18	COEFFICIENT NUMBER 19	COEFFICIENT NUMBER 20
.0	-.0016824	-.0208220	-.0001143	.0168477	.0082181
5.0	-.0015856	-.0215630	-.0000686	.0165905	.0154737
10.0	-.0014887	-.0223040	-.0000228	.0163334	.0227293
15.0	-.0027311	-.0260869	.0000262	.0195928	.0388110
20.0	-.0039735	-.0298697	.0000752	.0228522	.0548927
25.0	-.0034911	-.0392140	.0001828	.0213248	.0800975
30.0	-.0030087	-.0485583	.0002903	.0197973	.1053023
35.0	.0089770	-.0828991	.0001650	-.0013962	.1640302
40.0	.0194314	-.0753931	.0000295	-.0374368	.2291125
45.0	.0083993	-.0438761	-.0004262	-.0288949	.1497065
50.0	.0005261	-.0213831	-.0006253	-.0240698	.0629437
55.0	-.0055854	-.0203636	-.0016968	.0201478	.0223358
60.0	-.0039065	-.0191650	-.0006094	.0018075	.0105868
65.0	-.0087419	-.0148133	-.0010423	.0124199	.0110045
70.0	-.0023819	-.0128354	-.0018286	-.0035116	-.0055115
75.0	.0032863	-.0164898	-.0024699	.0001304	-.0003824
80.0	.0089545	-.0201442	-.0031112	.0037724	.0047467
85.0	.0071860	-.0198601	-.0031160	.0020125	.0008279
90.0	.0054175	-.0195761	-.0031208	.0002525	-.0030908

USABLE COEF ARRAYS

ALPHA	COEFFICIENT NUMBER 21	COEFFICIENT NUMBER 22	COEFFICIENT NUMBER 23	COEFFICIENT NUMBER 24
.0	-.0025167	-.1785060	-.0839098	.0014487
5.0	-.0026699	-.1372942	-.0829461	.0052931
10.0	-.0028231	-.0960824	-.0819823	.0091377
15.0	-.0034507	-.1294753	-.0899638	.0159290
20.0	-.0040782	-.1629056	-.0979453	.0227204
25.0	-.0044525	-.3550106	-.1100814	.0393505
30.0	-.0048269	-.5471174	-.1222176	.0578494
35.0	-.0040495	-.8043712	-.1340189	.0576849
40.0	-.0032084	-1.0734729	-.1429977	.0633174
45.0	-.0007394	-1.2383538	-.1400095	.0611179
50.0	.0035618	-1.2680484	-.1055780	.0676679
55.0	.0141496	-1.0596628	-.0890828	.0657991
60.0	.0049844	-.9195243	-.0759424	.0554032
65.0	.0066118	-.7337694	-.0568502	.0566141
70.0	.0036481	-.5476594	-.0487912	.0622597
75.0	.0015559	-.3712483	-.0259101	.0706560
80.0	-.0005363	-.1948371	-.0030291	.0790524
85.0	-.0017499	-.1088703	-.0295080	.0579690
90.0	-.0029636	-.0229035	-.0559869	.0368875

```
PØT SETTINGS

PØT(0)  = .23503          PØT(25) = .15587
PØT(1)  = .10005          PØT(26) = .50921
PØT(2)  = .31500          PØT(27) = .06030
PØT(3)  = .04174          PØT(30) = .06030
PØT(4)  = .12768          PØT(31) = .03796
PØT(5)  = .31500          PØT(32) = .59034
PØT(6)  = .02757          PØT(33) = .94500
PØT(7)  = .04064          PØT(34) = .14000
PØT(10) = .42100          PØT(35) = .16750
PØT(11) = .07482          PØT(36) = .03570
PØT(12) = .17863          PØT(37) = .20000
PØT(13) = .32700          PØT(40) = .09620
PØT(14) = .25407          PØT(41) = .28000
PØT(15) = .02600          PØT(42) = .04318
PØT(16) = .11400          PØT(43) = .08200
PØT(17) = .50000          PØT(44) = .10286
PØT(20) = .57000          PØT(45) = .17863
PØT(21) = .02002          PØT(46) = .00010
PØT(22) = .02002          PØT(50) = .19000
PØT(23) = .02002          PØT(52) = .02500
PØT(24) = .12061          PØT(53) = .99990
```

```
THE OUTPUTS OF THE AMPLIFIERS ARE REPRESENTATIVE OF THE FOLLOWING SCALED VARIABLES:

A000 INDICATES -PDOT/ 9.92    A001 INDICATES +P/ 3.15       A002 INDICATES -QDOT/ 9.92
A055 INDICATES +Q/ 3.15       A006 INDICATES -RDOT/17.72    A007 INDICATES +R/ 4.21
A015 INDICATES +T/RMASS/40.   A017 INDICATES -SX/52632.     A051 INDICATES -SY/52632.
A027 INDICATES -SZ/52632.     A024 INDICATES DIT/22.        A025 INDICATES THETA/200.
A026 INDICATES DA/13.         A031 INDICATES BETA/47.       A033 INDICATES PHI/400.
A034 INDICATES QUE/740.09     A035 INDICATES PSI/400.       A036 INDICATES VEL/1054.
A041 INDICATES DR/22.         A045 INDICATES ALPHA/116.

THE D/A TRUNKS REPRESENT THE FOLLOWING SCALED VARIABLES:

T420 INDICATES VDOT/40.       T421 INDICATES -ALPHADOT/3.1  T422 INDICATES -BETADOT/4.2
T423 INDICATES -PSIDOT/4.2    T424 INDICATES -THETADOT/4.2  T425 INDICATES -PHIDOT/4.2
T426 INDICATES ALI/9.92       T427 INDICATES SXDOT/1054.    T430 INDICATES SYDOT/1054.
T431 INDICATES SZDOT/1054.    T432 INDICATES AMI/9.92       T433 INDICATES ANI/17.72
```

EARTH GRID REFERENCE LINES

	START			END		
LINE	X	Y	Z	X	Y	Z
1	500000.	-21000.	0.	-500000.	-21000.	0.
2	500000.	-14000.	0.	-500000.	-14000.	0.
3	500000.	-7000.	0.	-500000.	-7000.	0.
4	500000.	0.	0.	-500000.	0.	0.
5	500000.	7000.	0.	-500000.	7000.	0.
6	500000.	14000.	0.	-500000.	14000.	0.
7	500000.	21000.	0.	-500000.	21000.	0.
8	21000.	500000.	0.	21000.	-500000.	0.
9	14000.	500000.	0.	14000.	-500000.	0.
10	7000.	500000.	0.	7000.	-500000.	0.
11	0.	500000.	0.	0.	-500000.	0.
12	-7000.	500000.	0.	-7000.	-500000.	0.
13	-14000.	500000.	0.	-14000.	-500000.	0.
14	-21000.	500000.	0.	-21000.	-500000.	0.

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UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Naval Postgraduate School Monterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

IMPLEMENTATION OF A FIXED-BASE SPIN SIMULATOR

4. DESCRIPTIVE NOTES *(Type of report and, inclusive dates)*
Master's Thesis; September 1972

5. AUTHOR(S) *(First name, middle initial, last name)*

Bruce Holladay Kenton; Lieutenant, United States Navy

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1972	138	5

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

This report discusses the design and implementation of a fixed-based spin simulator and the results derived from conducting preliminary spin tests on the simulator.

The central piece of equipment in the simulator was a hybrid computer in which the analog computer solved the equations of motion while the digital computer performed the tasks of program control and aerodynamic data storage. The visual display consisted of a computer-drawn picture on a graphics terminal, while pilot control was obtained by use of a simulated cockpit situated in front of the graphics terminal.

Results showed that the simulator displayed excellent dynamic response characteristics and provided sufficient visual cues to perform meaningful spin tests.

This project was a continuation of previous work and has shown that the design and construction of this simulator has been an excellent research tool and source for further study in the field of control systems and aircraft dynamics.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
SPIN SIMULATOR						

DD FORM 1 NOV 65 1473 (BACK)
S/N 0101-807-6821